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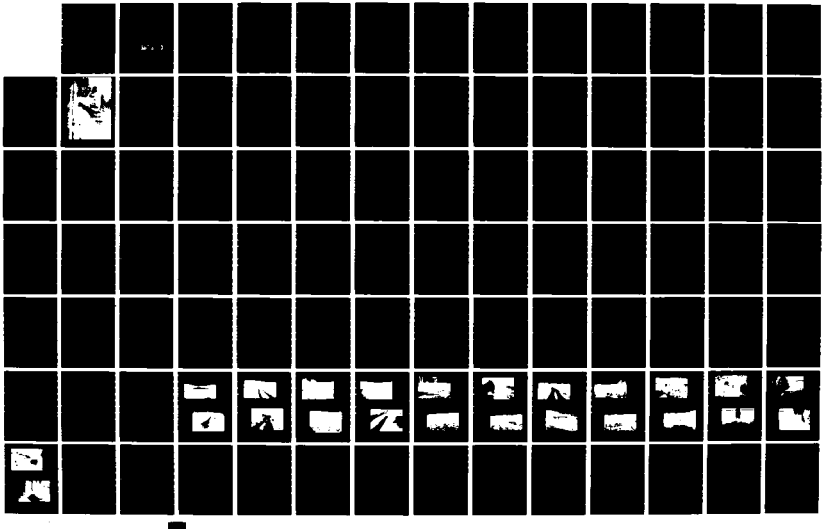

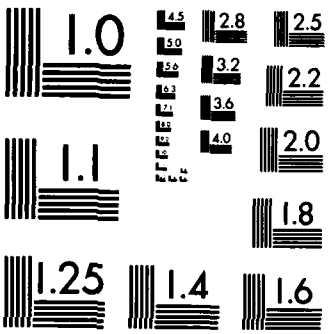

ST. FRANCIS RIVER BASIN

NORTON, VERMONT

NORTON POND DAM

VT 00198

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

JANUARY 1979

UNCLASSIFIED

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St. Francis River Basin
Norton, Vt.
Coaticook River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

TXe dam is a 1200 ft. long, 13 ft. high earth embankment dam. TSe dam is in poor condtion with various concerns which must be corrected. TDe dam is intermediate in size with a significant hazard potential.THere are various remedial measures and recommendations which must be undertaken by the owner.

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REPLY TO
ATTENTION OF

NEDED

MAY 2 1979

Honorable Richard A. Snelling
Governor of the State of Vermont
State Capitol
Montpelier, Vermont 05602

Dear Governor Snelling:

I am forwarding to you a copy of the Norton Pond Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Water Resources, the cooperating agency for the State of Vermont. In addition, a copy of the report has also been furnished the owner, Coaticook River Water Power Company Coaticook, Quebec, Canada .

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Water Resources for your cooperation in carrying out this program.

Sincerely yours,

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

NORTON POND DAM

VT 00198

ST. FRANCIS RIVER BASIN
NORTON, VERMONT

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LETTER OF TRANSMITTAL

FROM THE CORPS OF ENGINEERS TO THE STATE

TO BE SUPPLIED BY THE CORPS OF ENGINEERS

NATIONAL DAM INSPECTION PROGRAM
PHASE I - INSPECTION REPORT
BRIEF ASSESSMENT

Identification No.: 00198

Name of Dam: Norton Pond Dam

Town: Norton

County and State: Essex, Vermont

Stream: Coaticook River

Date of Inspection: November 10, 1978

Norton Pond Dam is a 1200 foot long, 13 foot high earth embankment dam. This dam was originally constructed in 1893, with repairs being made in 1930 and 1945. The appurtenant works consist of a concrete spillway and outlet works structure. The spillway consists of two crest openings, each about 9'-9" long and separated by a 2 foot pier. The outlet works consist of two concrete sluiceways, 5 feet high by 4 feet wide and 40 feet long. Discharge is controlled by two hand-operated slide gates. Engineering data available consisted of a set of plans dated 1947 showing plan, elevation and details of the dam. No construction specifications or design calculations were available.

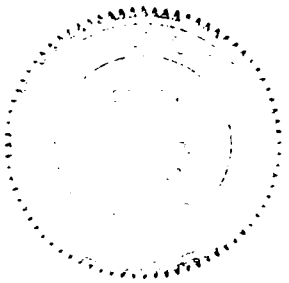
The visual inspection of Norton Pond Dam indicated that it is in poor condition. The inspection revealed that the upstream slope of the embankment has sloughed and has been eroded in several locations and that the soil exposed by the sloughing is a silty fine to coarse sand which is loose and subject to continued erosion. The downstream slope, which at the time of inspection was covered with an impenetrable cover of brush and thorn bushes is, in some places, on a slope of about one foot vertical to one foot horizontal. Also, the inspection revealed heavy cracking and spalling of concrete at the spillway and outlet works structures, gates in poor or inoperable condition, excessive amounts of log and stump debris in the reservoir immediately upstream of the dam and downstream channel obstruction caused by overhanging trees and brush.

Based on the dam's intermediate size and significant hazard classification in accordance with the Corps guidelines the test flood is one-half the PMF. The spillway

will pass only about 8 percent of the test flood and is considered inadequate. The nonoverflow section would be overtopped by 2.7 feet under test flood conditions.

It is recommended that the owner clean the downstream slope of the dam to permit adequate inspection for seepage through and beneath the dam and engage a qualified engineer to further evaluate the potential for overtopping, the inadequacy of the spillway and the feasibility of significantly increasing discharge capacity. Provisions should be made by the owner to repair the sloughing on the upstream face of the dam, remove floating debris and provide suitable riprap on the upstream slope, install a log boom across the intake channel of the spillway outlet works, repair deteriorated sections of concrete at the spillway/outlet works structures and replace or repair the outlet control gates. It is also recommended that spillway stoplogs be removed and the reservoir level be kept at the spillway elevation of 1330.96 until the recommendations and remedial measures are accomplished.

The recommendations and remedial measures are described in Section 7. The remedial measures (Section 7.3) should be addressed within six months and the recommendations (Section 7.2) should be addressed within one year after receipt of this Phase I - Inspection Report by the owner.



Gordon H. Slaney, Jr.

Gordon H. Slaney, Jr.
Project Engineer

Howard, Needles, Tammen & Bergendoff
Boston, Massachusetts

This Phase I Inspection Report on Norton Pond Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Joseph W. Finegan

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Joseph A. McElroy

JOSEPH A. MCELROY, CHAIRMAN
Chief, NED Materials Testing Lab.
Foundations & Materials Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there by any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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A drainage ditch, parallel to the base of the dam was apparently excavated at the toe to carry away the seepage flow which was a steady stream at the time of the visit." The earlier observations of seepage through the dam could not be confirmed at the time of inspection because of the dense growth on the downstream face of the dam. It is recommended that the spillway stoplogs be removed and reservoir level not be raised above the spillway elevation of 1330.96 until the upstream sloughing and erosion has been repaired and until the downstream face has been cleared to permit a thorough examination of that face of the dam and the area immediately below the downstream toe.

banks, there is an accumulation of a great number of logs and stumps. The extent of this debris is such that it could create blockage of the spillway and outlet works under nearly all flow conditions. The amount of siltation within the reservoir is unknown.

e. Downstream Channel. Immediately downstream of the dam, there is a small pool with many dead logs on both banks. Downstream of the pool, the channel passes through a heavily wooded area with brush overhanding both banks which could create an obstruction to flow.

3.2 Evaluation

Visual examination indicates that the overall condition of the dam is poor. The inspection of the dam revealed the following:

(a) The upstream slope of the embankment has sloughed and has been eroded in several locations, and in two locations, the sloughing has progressed into the embankment crest.

(b) The soil exposed by the sloughing is a silty fine to coarse sand which is loose and subject to continued erosion.

(c) The downstream slope, which at the time of inspection was covered with a impeneratable cover of brush and thorn bushes is, in some places, on a slope of about 1 foot vertical to 1 foot horizontal.

(d) Heavily cracked and spalling concrete on both training walls of the spillway section and the intermediate pier supporting the log roadway bridge over the spillway.

(e) Deteriorating of the concrete outlet works culvert.

(f) One of two control gates is inoperable. Wooden portions of both gates are rotted and metal portions are rusted.

(g) Excessive amounts of log and stump debris in the reservoir immediately upstream of the dam.

(h) Downstream channel obstruction caused by dense, overhanging trees and brush.

Prior inspection by the Vermont Public Service Commission states that seepage through and under the dam had been seen. Quoting from this report dated June 30, 1948, "Spring-like flow emerging from the embankment was observed in a few places.

Downstream Slope

The face of the downstream slope is covered with dense brush which prevented an adequate inspection of this face and the downstream toe of the dam. Photo 7 is a typical view of the downstream face.

c. Appurtenant Structures. Visual inspection of the concrete spillway, outlet works structure and spillway/outlet works discharge channel did not reveal any evidence of stability problems. The concrete surface of these structures, however, was found to be in generally poor condition; cracks and heavy spalling were noted throughout the concrete surface as shown in Photos 20, 21, 22, 23 and 24.

The spillway structure consists of a concrete sloped slab with flash boards located at the upper face as shown on Section A-A, Figure 1, located in Appendix B. The concrete surface of the spillway slab appeared to be in generally good condition. The training walls and intermediate pier supporting the log roadway bridge, however, are heavily cracked and spalled. The extent of this deterioration can be seen in Photos 20, 21, 22, 23 and 24.

The outlet works structure, shown in Photos 18 and 24, is formed by a concrete box culvert type structure. The outlet works contains two sections, each with an effective opening of 4 feet wide by 5 feet high, controlled by two mechanically operated wooden gates. The left gate is not operational. Both gates, including their control mechanism, are in poor condition. The wooden parts of each gate are rotted, and the metal parts are very rusted. The concrete forming this structure also appears to be in poor condition as can be seen in Photos 23 and 24. Photo 24 shows the condition of the culvert at downstream face. The deteriorated concrete observed during the visual inspection will, if corrective action is not taken, be exposed to further deterioration and may eventually lead to partial or complete collapse of this structure.

d. Reservoir Area. The reservoir area slopes consist of heavily wooded, mountainous terrain. The watershed is substantially undeveloped with only one road and railroad line passing through the basin, both of which run along the east side of the reservoir. There are about a dozen dwellings along the southeasterly shore. Within the reservoir there are approximately eight small islands. In the immediate vicinity of the dam and along a substantial portion of the reservoir

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The field inspection of Norton Pond Dam was made on November 10, 1978. The inspection team consisted of personnel from Howard, Needles, Tammen & Bergendoff and Geotechnical Engineers, Inc. A representative of the Coaticook River Water Power Company was also present during a portion of the inspection. Inspection checklists, completed during the visual inspection are included in Appendix A. At the time of the inspection, the water level was approximately 5 inches below the permanent spillway elevation. No water was passing over the spillway. The upstream face of the dam could only be inspected above this water level.

b. Dam. Visual inspection of the dam indicated it is in fair condition. The upstream slope of the dam has experienced sloughing and erosion in several areas which should be repaired before the reservoir level is allowed to exceed the spillway elevation of 1330.96.

Upstream Slope

Photos 9, 11, 14 and 15 show the small scale slides or sloughing which have occurred on the upstream slope.

At two locations, Station 2+23 shown in Photos 10, 11 and 12, and Station 5+54 shown in Photo 14, the sloughing and erosion has progressed into the embankment crest.

The soil exposed by the sloughing is a silty fine to coarse sand which is loose and subject to continued erosion.

As demonstrated by Photo 14, riprap slope protection is nonexistent in some sections of the dam for a distance of 4 feet below the crest. The water level is often raised to within one foot of the crest elevation.

Crest

The crest width varies between 8 and 12 feet and is unpaved. A typical section of the crest is shown in Photo 13. No evidence of cracking or misalignment that could be attributed to embankment movement was observed.

SECTION 2
ENGINEERING DATA

2.1 Design

No original design data were disclosed for Norton Pond. The dam was originally constructed in 1893. A set of drawings (2 sheets) prepared by W. S. Lea, Consulting Engineer, dated 1947 showing plan, sections and details of the dam is the only design information found.

2.2 Construction

No construction records were available for use in evaluating the dam.

2.3 Operation

No engineering operational data were disclosed.

2.4 Evaluation

a. Availability. Engineering data available for Norton Pond Dam is limited to the set of drawings mentioned above. This plan is on file at the State of Vermont, Public Service Board.

b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgement.

c. Validity. The field investigation indicated that the external features of Norton Pond Dam substantially agree with those shown on the available plans.

j. Outlet Works. The outlet works consist of two 4 feet wide by 5 feet high gates set at an invert elevation of 1,323.91. The left gate is in a closed position and is not operable. The right gate is opened several inches to provide flow downstream.

(2) Flood Control Pool - N/A

(3) Spillway Crest - 570.

(4) Test Flood Pool - 570.

(5) Top Dam - 570.

g. Dam

(1) Type - earth embankment.

(2) Length - 1,200 feet, overall.

(3) Height - 13 feet (maximum).

(4) Top Width - 10 (average).

(5) Side Slopes - US = 1½:1; DS = variable.

(6) Zoning - unknown.

(7) Impervious core - unknown.

(8) Cutoff - unknown.

(9) Grout Curtain - unknown.

(10) Other - none.

h. Diversion and Regulating Tunnel

None.

i. Spillway

(1) Type - concrete sluice.

(2) Length of Weir - 19.42 feet (9'-9" + 9'-8").

(3) Crest Elevation - 1,330.96.

(4) Gates - stoplogs (six high).

(5) U/S Channel - none.

(6) Downstream Channel. Immediately downstream of the dam there is a small pool with many dead logs on both banks. Downstream of the pool the channel passes through a heavily wooded area with brush overhanging both banks.

(3) The spillway capacity with the pond level at the top of dam is approximately 180 cfs with the stoplogs in place. Top of dam elevation is 1,336.8 feet. With the stoplogs removed the spillway capacity at this elevation is about 820 cfs.

(4) The spillway capacity (stoplogs in place) at the test flood elevation of 1,339.5 is approximately 500 cfs. With the stoplogs removed, the spillway capacity at this elevation is about 1,960 cfs.

(5) The total project discharge at the test flood elevation of 1,339.5 is approximately 10,600 cfs.

c. Elevation (feet above MSL)

(1) Streambed at centerline of dam - 1,322±.

(2) Maximum tailwater - unknown.

(3) Upstream portal invert diversion tunnel - none.

(4) Recreation pool - 1,335.

(5) Full flood control pool - N/A

(6) Spillway crest (permanent spillway) - 1,330.96.

(7) Design surcharge - unknown.

(8) Top Dam - 1,336.8.

(9) Test Flood Surcharge - 1,339.5.

d. Reservoir (miles)

(1) Length of Maximum Pool - 2.8.

(2) Length of Recreational Pool - 2.8.

(3) Length of Flood Control Pool - N/A

e. Storage (gross acre-feet)

(1) Recreation Pool - 1950.

(2) Flood Control Pool - N/A

(3) Spillway Crest Pool - 1,950.

(4) Top of Dam - 3,660.

f. Reservoir Surface (acres) - vertical sides assumed.

(1) Recreation Pool - 570.

by W. S. Lea and are on file with the Sate of Vermont, Public Service Board.

i. Normal Operating Procedure. Stoplogs are usually left in place in the spillway channel to within one foot of the top of structure to form a weir outlet. One of the two sluiceway gates is left open several inches to maintain minimum flows in the downstream channel. The pond level is maintained at the top of the stoplogs as long as runoff will provide.

1.3 Pertinent Data

a. Drainage Area. The tributary area above Norton Pond Dam consists of 17.3 square miles of heavily wooded, mountainous terrain. There are seven different inflow points to the reservoir. The watershed is totally undeveloped with only one road and railway line passing through the basin.

The lake area of 570 acres is bounded on one side by the above mentioned road and railway. There are about a dozen dwellings along the southeasterly shore. Within the lake there are eight small islands. Topographic elevation in the watershed ranges from 2,920 to 1,335 feet MSL.

b. Discharge at Dam Site

(1) The outlet works for Norton Pond consist of two concrete sluiceways, 5 feet high by 4 feet wide and 40 feet long. Discharge is controlled by two mechanically operated gates. Adjacent to the sluiceway is a concrete spillway structure with two crest openings, each about 9'-9" long and separated by a 2 foot pier. The spillway crest is about 5 feet below the top of the concrete structure and about 6 feet below the top of the dam. Stoplogs of 3 inch plank control the flow over the spillway. The outlet works sluiceway is located at an elevation of about 1,324 and if the gates are opened, would allow the water level in the pond to be lowered to within 2 or 3 feet of the original Coaticook River channel bed.

(2) There are no records of maximum discharge at the dam site. In July 1942, sandbags were placed on the crest to prevent overtopping of the embankment. In April of 1945 a 150 foot section of the dam was overtopped, and a partial washout of the earth embankment occurred to the right of the spillway section.

b. Description of Dam and Appurtenances. Norton Pond Dam is an earthfill structure approximately 1,200 feet long. The maximum structural height of the dam, according to existing plans, is about 13 feet. The exact nature and distribution of materials used for the dam's construction is unknown. The upstream and downstream face of the dam has a variable slope ranging from 1.5 feet horizontal and 1 foot vertical to 3 feet horizontal and 1 foot vertical.

The appurtenant works consist of a concrete spillway with stoplogs and two concrete sluiceways, 5 feet high by 4 feet wide and 40 feet long. Discharge is controlled by two hand operated slide gates. The spillway/outlet works structure is located in the original Coaticook River bed.

Figure 1, located in Appendix B, shows the plan of the dam, spillway and outlet works. Photographs of each structure are shown in Appendix C.

c. Size Classification. Intermediate (hydraulic height - 12 feet high, storage - 3,660 acre-feet) based on storage ($\geq$1,000 to 50,000 acre-feet) as give in Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. The dam's potential for damage rates it as a significant hazard classification. A major breach of dam could possibly result in property damage and the loss of a few lives in Norton, located 5 miles downstream. The estimated flood stage is about 8 feet high which could possibly affect 2 or 3 dwellings between the dam and the town and several dwellings in the town itself.

e. Ownership. This dam is owned by the Coaticook River Water Power Comany, Coaticook, Quebec, Canada.

f. Operator. This dam is maintained and operated by the Coaticook River Water Power Company. The dam operator is Mr. Marshall Benoit, Coaticook, Quebec. Telephone No. (819)849-2721.

g. Purpose of Dam. This dam is used to provide water storage for hydro-electric power generation in the Town of Coaticook, Quebec. Stored water is released as necessary by manual operation of the gate control in the outlet works sluiceway. Some recreational benefits are gained from the reservoir.

h. Design and Construction History. This dam was originally constructed in 1893. In 1930 a new outlet works and spillway were constructed. No design or construction data are available. In 1945, repairs were made to a partially washed out section of the dam. Plans of the dam were prepared

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
NORTON POND DAM

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Howard, Needles, Tammen & Bergendoff has been retained by the New England Division to inspect and report on selected dams in the State of Vermont. Authorization and notice to proceed were issued to Howard, Needles, Tammen & Bergendoff under a letter of October 23, 1978, from John P. Chandler, Colonel, Corps of Engineers. Contract No. DACW33-78-C-0356 has been assigned by the Corps of Engineers for this work.

b. Purpose

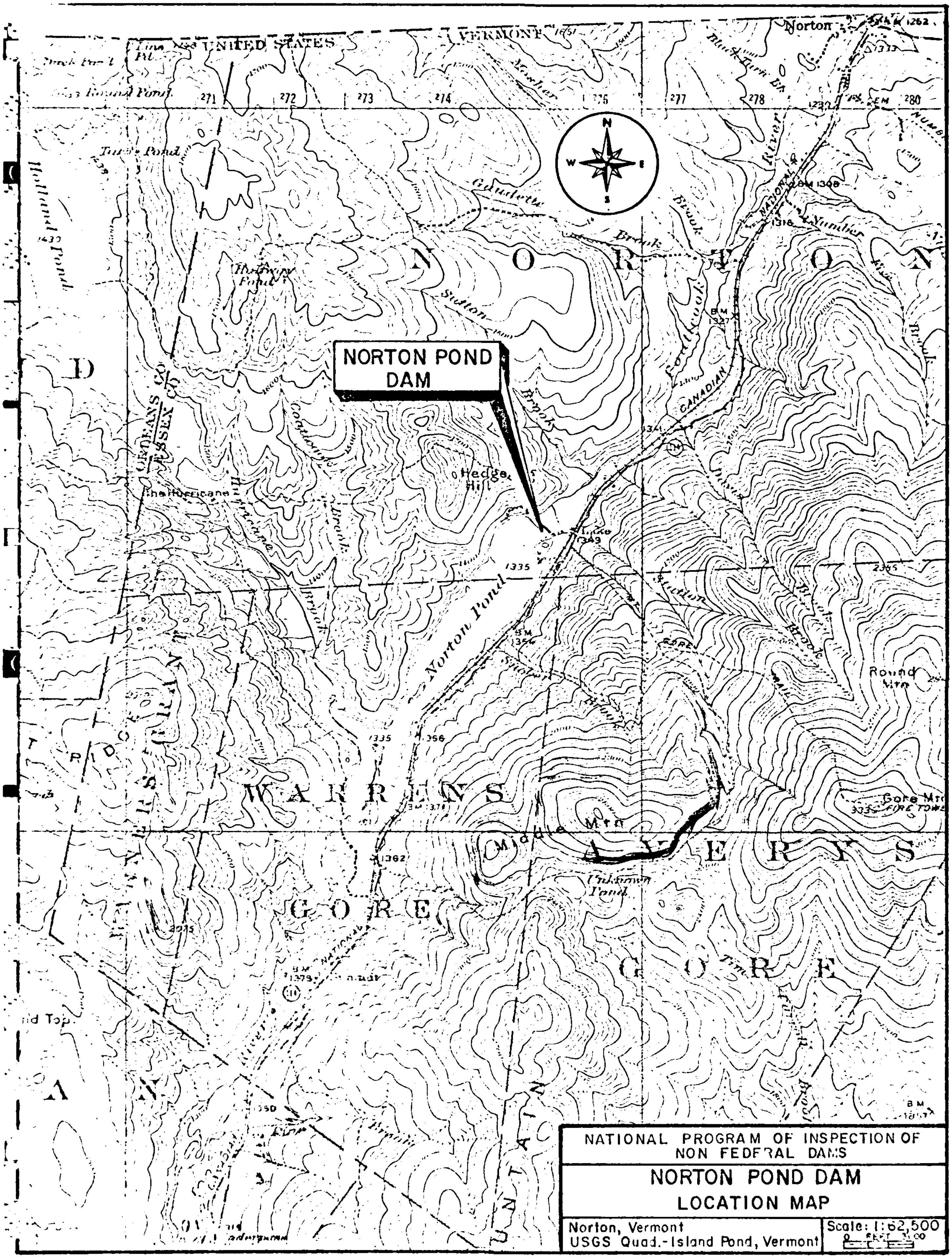
(1) To perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

(2) To encourage and prepare the states to initiate quickly effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. Norton Pond Dam is located on the Coaticook River approximately 5 miles upstream from the center of Norton, Vermont, in the Town of Norton, Vermont. The dam is shown on U.S.G.S. Quadrangle, Island Pond, Vermont, with approximate coordinates N44°57'10", W71°51'06" in Essex County, Vermont. The location of Norton Pond Dam is shown on the Location Plan immediately preceding this page.


NORTON POND
DAM
NATIONAL PROGRAM OF INSPECTION OF
NON FEDERAL DAMS
NORTON POND DAM
LOCATION MAP
Norton, Vermont
USGS Quad.-Island Pond, Vermont
Scale: 1:62,500

NORTON POND DAM - Overview from left abutment

APPENDIXES

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedure

Norton Pond Dam is used to provide water storage for hydro-electric power generation in the Town of Coaticook, Quebec. Some recreational benefits are also gained from the reservoir. Discussion with the owner revealed that normal operation has the stoplogs in the spillway channel set in place to within one foot of the top of the structure to form a weir outlet. One of the two sluiceway gates is left partially open to maintain a minimum flow downstream. The pond level is maintained at the top of the stoplog as long as runoff will provide.

4.2 Maintenance of Dam

Except for the repairs made to the dam embankment in May 1945, there appears to be no maintenance program established for this dam.

4.3 Maintenance of Operating Facilities

Some minor concrete repair work to the spillway channel has been accomplished in the recent past. Other than this, however, there appears to be no maintenance program for the operating facilities of this dam.

4.4 Description of Warning Systems

There are no warning systems in effect at this facility.

4.5 Evaluation

The current operation and maintenance procedures for Norton Pond Dam are inadequate to insure that all problems encountered can be remedied within a reasonable period of time. The maintenance procedures are considered to be poor. The owner should establish a written operation and maintenance procedure as well as establishing a warning system to follow in event of flood flow conditions or imminent dam failure.

SECTION 5
HYDROLOGY AND HYDRAULIC ANALYSIS

5.1 Evaluation of Features

a. General. Norton Pond Dam is an earthfill structure with a total length of approximately 1,200 feet and a maximum structural height of 14 feet. The appurtenant works consist of a concrete spillway and outlet works structure. The spillway consists of two crest openings, each about 9'-9" long and separated by a 2 foot pier. The spillway crest is about 5 feet below the top of the concrete structure and about 6 feet below the top of the dam. Stoplogs of 3 inch plank control the flow over the spillway. The outlet works consist of two concrete sluiceways, 5 feet high by 4 feet wide and 40 feet long. Discharge is controlled by two hand-operated slide gates.

The dam creates an impoundment of water primarily used for hydro-electric power generation. Norton Pond Dam is classified as being intermediate in size having a maximum storage of 3,660 acre-feet.

b. Design Data. No hydrologic or hydraulic design data were disclosed for Norton Pond.

c. Experience Data. The maximum discharge at this dam site is unknown. In July of 1942, sandbags were placed on the crest to prevent overtopping of the embankment. In April of 1945, a 150 section of the dam was overtopped and a partial washout of the earth embankment occurred to the right of the spillway section.

d. Visual Observations. Some evidence of small scale slides or sloughing was noted on the upstream face of the dam. The water level at this dam is often raised to within one foot of the crest elevation.

e. Overtopping Potential. As no detailed design and operational information are available, hydrologic evaluation was performed using dam information gathered by field inspection, watershed size and an estimated test flood equal to 1/2 the Probable Maximum Flood (PMF) as determined by guide curves issued by the Corps of Engineers. Based on a drainage area of 17.3 square miles, it was estimated that the test flood inflow at Norton Pond Dam would be 15,400 cfs. Following the guidance for Estimating Effect of Surcharge Storage on Maximum Probable

Discharge results in a test flood discharge of 10,600 cfs. As the maximum spillway capacity at the top of the dam, with all stoplogs removed, is only 820 cfs (approximately 7.7 percent of the test flood discharge flow), the test flood will result in the dam being overtopped by approximately 2.7 feet.

f. Dam Failure Analysis. The impact of failure of the dam at maximum pool (top of dam) was assessed using the "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs issued by the Corps of Engineers. The analysis covered the reach extending from the dam to Norton Center located five miles downstream. The peak outflow from a major dam failure does not have enough hydraulic head to pass through the downstream channel due to the low pool elevation and constricting downstream conditions. Using a stage equal to two-thirds the height of the dam, the expected flood wave stage in Norton, 5 miles downstream would be approximately 8.0 feet. This stage could be expected to cause damage to two buildings between the dam and the Town of Norton and several more dwellings in the town itself with the resultant possibility of the loss of a few lives.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observation. The visual inspection disclosed sloughing and erosion on the upstream face which should be repaired before the reservoir is allowed to be raised above 1330.96.

b. Design and Construction Data. Norton Dam is an earth-fill dam about 1,200 feet long. The embankment averages between 8 and 10 feet in height. The maximum structural height is about 13 feet. The width of the crest varies between 8 and 12 feet. The side slopes vary from 1 foot vertical to 1 foot horizontal (1:1) to 1:2 with the upstream slope generally flatter than the downstream slope.

The original dam was built in about 1893 and a new outlet works and spillway was added about 1930. Drawings dated November 1947 indicate the fill material is clay and gravel, but examination of sloughed areas during this inspection indicate the material used for construction is a silty fine to coarse sand.

c. Operating Records. In July 1942, sandbags were placed on the crest to prevent overtopping of the embankment.

On April 10, 1945, a 150 foot section of the embankment adjacent to the spillway was overtopped and eroded to a depth of as much as 3 feet. This section of the embankment was repaired in May 1945.

d. Post-Construction Changes. Since the original construction, a new outlet structure has been constructed near the left abutment of the dam. This outlet structure provides a maximum waterway opening of 8 feet wide by 10 feet high. This new structure was constructed in about 1930.

e. Seismic Stability. The dam is located in Seismic Zone 2, and in accordance with recommended Phase I guidelines does not warrant seismic analysis.

SECTION 7
ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual inspection of Norton Pond Dam did not disclose any findings that indicate an immediate unsafe condition. The overall observed condition of the dam was poor. The inspection revealed the following:

(1) The upstream slope of the embankment has sloughed and has been eroded in several locations, and in two locations, the sloughing has progressed into the embankment crest.

(2) The soil exposed by the sloughing is a silty fine to coarse sand which is loose and subject to continued erosion.

(3) The downstream slope, which at the time of inspection was covered with an impenetrable cover of brush and thorn bushes is, in some places, on a slope of about 1 foot vertical to 1 foot horizontal.

(4) Heavily cracked and spalling concrete on both training walls of the spillway section and the intermediate pier supporting the log roadway bridge over the spillway.

(5) Deteriorating of the concrete outlet works culvert.

(6) One of two control gates is inoperable. Wooden portions of both gates are rotted and metal portions are rusted.

(7) Excessive amounts of log and stump debris in the reservoir immediately upstream of the dam.

(8) Downstream channel obstruction caused by dense, overhanging trees and brush.

The hydraulic analyais reveals that the dam cannot pass the required test flood without overtopping the dam.

b. Adequacy of Information. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgment.

c. Urgency. This dam is in generally poor condition. The recommendations described in Section 7.2 should be accomplished within one year after receipt of this Phase I Inspection Report by the owner. The remedial measures described in Section 7.3 should be addressed within six months after receipt of this Phase I Inspection Report by the owner.

d. Necessity of Additional Investigation. Due to impeneterable growth of bushes, the downstream slope could not be adequately inspected. Since seepage has been noted on the downstream slope in earlier inspection, the existing brush should be cut to permit a more complete examination of the downstream slope of the dam.

7.2 Recommendations

It is recommended that the owner clean the downstream slope of the dam to permit adequate inspection for seepage through and beneath the dam. It is also recommended that the owner engage a qualified engineer to further evaluate the potential for overtopping, the inadequacy of the spillway and to determine what alternative measures are necessary to significantly increase the discharge capabilities of the dam.

7.3 Remedial Measures

(a) The sloughing on the upstream face of the dam should be repaired.

(b) All logs and debris should be removed from the upstream area of the dam.

(c) Suitable riprap should be installed to protect the upstream slope of the dam.

(d) A log boom should be installed across the intake channel of the spillway outlet works.

(e) The cracked and spalling concrete of both training walls and intermediate pier of the spillway section and the outlet works culvert should be repaired.

(f) The control gates should be repaired or replaced.

(g) The bridge over the spillway should be anchored down to supports and reinforced where necessary to prevent washout and/or collapse.

(h) The downstream channel should be cleared of logs and dense overhanging trees and brush.

(i) The spillway stoplogs should be removed and the reservoir elevation should be kept at the spillway elevation of 1330.96 until remedial measures a through h and the recommendations of Section 7.2 have been implemented.

(j) A written operational procedure and warning system to follow in the event of flood flow conditions or imminent dam failure should be developed. The warning system should discuss the operation of the gates during flood flow conditions and the steps to be taken by local officials for alerting downstream residents in case of emergency.

(k) An annual periodic technical inspection program should be initiated.

7.4 Alternatives

There are no practical alternatives to the recommendations of Section 7.2 and 7.3.

APPENDIX A

VISUAL CHECKLIST WITH COMMENTS

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Norton Pond Dam

DATE Nov. 10, 1978

TIME 1:00 P.M.

WEATHER Cloudy

W.S. ELEV 1330.5 U.S. 1324± DN.S

PARTY:

1. Gordon Slaney, HNTB
2. Stan Mazur, HNTB
3. Dan LaGatta, GEI
4.
5.
6.
7.
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Dam	Dan LaGatta	
2.	Spillway/Outlet Works	S. Mazur, G. Slaney	
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

PERIODIC INSPECTION CHECK LIST

PROJECT Norton Pond Dam DATE Nov. 10, 1978

PROJECT FEATURE Embankment Dam NAME D. P. LaGatta

DISCIPLINE Geotechnical Engineer NAME

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	1,336.8
Current Pool Elevation	1,330.5
Maximum Impoundment to Date	Overtopped 1945.
Surface Cracks	None observed.
Pavement Condition	No pavement.
Movement or Settlement of Crest	None observed.
Lateral Movement	None observed.
Vertical Alignment	No misalignment observed.
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	Good.
Indications of Movement of Structural Items on Slopes	No structures on slope.
Trespassing on Slopes	None.
Sloughing or Erosion of Slopes or Abutments	Sloughing and erosion has occurred in several places.
Rock Slope Protection - Riprap Failures	Riprap is poor and/or missing in places on upstream slope.
Unusual Movement or Cracking at or near Toes	None observed.
Unusual Embankment or Downstream Seepage	None observed - dense growth prevented detailed examination of area long downstream toe.
Piping or Boils	
Foundation Drainage Features	None.
Toe Drains	None.
Instrumentation System	None.
Vegetation	Dense bushes on d.s. slope.

PERIODIC INSPECTION CHECK LIST

PROJECT Norton Pond Dam DATE Nov. 10, 1978

PROJECT FEATURE Intake Channel/Structure NAME D. LaGatta,

DISCIPLINE Structural/Hydraulic/Geotechnical Engineers NAME S. Mazur, G. Slaney

AREA EVALUATED	CONDITION
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	There is no special approach channel for this dam.
Slope Conditions	
Bottom Conditions	
Rock Slides or Falls	
Log Boom	
Debris	
Condition of Concrete Lining	
Drains or Weep Holes	
b. Intake Structure	
Condition of Concrete	Fair.
Stop Logs and Slots	Fair.

PERIODIC INSPECTION CHECK LIST

PROJECT Norton Pond Dam — DATE Nov. 10, 1978

PROJECT FEATURE Outlet Works/Controls — NAME S. Mazur

DISCIPLINE Structural Engineer — NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - CONTROL TOWER	
a. Concrete and Structural	Outlet works structure consists of a box-culvert concrete structure and two mechanically controlled wooden gates.
General Condition	Fair.
Condition of Joints	Fair.
Spalling	Some spalling observed.
Visible Reinforcing	None observed.
Rusting or Staining of Concrete	Some amount observed.
Any Seepage or Efflorescence	None observed.
Joint Alignment	Good.
Unusual Seepage or Leaks in Gate Chamber	None observed.
Cracks	Numerous observed.
Rusting or Corrosion of Steel	None observed.
b. Mechanical and Electrical	
Air Vents	Manually operated mechanical controls for two wooden gates. Left gate is not functioning. Wooden gates below water and therefore not inspected. Gear mechanism on both gates in relatively poor condition.
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System	

PERIODIC INSPECTION CHECK LIST

PROJECT Norton Pond Dam DATE Nov. 10, 1978

PROJECT FEATURE Transition and Conduit NAME

DISCIPLINE NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - TRANSITION AND CONDUIT	
General Condition of Concrete	None.
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

PERIODIC INSPECTION CHECK LIST

PROJECT Norton Pond Dam — DATE Nov. 10, 1978

PROJECT FEATURE Outlet Structure/Channel — NAME D. LaGatta

DISCIPLINE Structural/Hydraulic/Geotechnical Engineers — NAME S. Mazur, G. Slaney

AREA EVALUATED	CONDITION
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	Box-culvert sluiceway is only way of outletting water other than spillway, consists of mechanically control wooden gates (see also Outlet Works-Control Tower).
General Condition of Concrete	Fair.
Rust or Staining	Some rust.
Spalling	Heavy spalling.
Erosion or Cavitation	None observed.
Visible Reinforcing	None observed.
Any Seepage or Efflorescence	None.
Condition at Joints	Good.
Drain Holes	None.
Channel	Concrete training walls and riprap with section of embankment.
Loose Rock or Trees Overhanging Channel	None.
Condition of Discharge Channel	Good.

from the embankment was observed in a few places. A drainage ditch, parallel to base of the dam was apparently excavated at the toe to carry away the seepage flow which was a steady stream at the time of the visit. This seepage condition is an unhealthy one for the dam. Any increase in reservoir level may be just enough to induce serious piping and sloughing of the downstream toe, resulting in failure by an embankment slide. Some form of toe stability should be provided and the seepage controlled.

Stephen H. Haybrook

STEPHEN H. HAYBROOK
HYDRAULIC ENGINEER

Public Service Commission

June 30, 1948

due to the assumed flood is about 2 ft. as compared to a 4 ft. rise for the 20 ft. spillway. Thus, with the 50 ft. spillway, the height of the embankment, including freeboard, can be about 2 ft. lower provided that the regulation at the beginning of the flood is the same as for the 20 ft. spillway.

If desired, it is possible to arrive at a length of spillway where the human element is eliminated; that is, it will not be necessary to rely on someone to remove the stoplogs and open the gates at the time of the flood.

Comments on Inspection of the Dam

The writer visited the site on June 23, 1948 to inspect the dam, and makes the following comments:

There is indication of new fill added to the dam. According to the owner of the dam, the height of the new fill is about one foot. The new fill appears to be a clayey material, similar to that in the old embankment. A layer of gravel has been added to the top of the dam.

The side slopes have no slope protection. Numerous gullies appear on the downstream face due to rainwater washing down the slope. The upstream face is subjected to continuous pounding and erosion due to floating debris, wave action, and ice conditions.

Much floating debris has accumulated just upstream from the dam and should be removed for appearance's sake. However, the floating debris may have a dampening effect on wave action. A boom before the spillway protects it and the sluiceway from this accumulation.

The sluice gates appear in good condition. It was noted that one interchangeable sprocket for manual operation is used for the two gates.

An inspection of the downstream face and toe of the dam disclosed evidence of seepage through and under the dam. Spring-like flow emerging

mi. for the Coaticook River at Coaticook, Quebec. The drainage area is about 150 sq. mi. Note that this flood peak, on the same stream as Norton Dam, agrees very closely with the curve of Fig. 1.

The maximum flood flow at Norton Dam will probably occur rarely and perhaps will be approached only once in a hundred years or more. Yet one must recognize the possibility of it being approached or exceeded at any time. The degree of conservation for Norton Dam must consider the fact that it is an earth fill dam, the overtopping of which is much more dangerous than in the case of a concrete dam.

At Norton Dam the shape of the drainage area provides an added factor of safety when considered in the determination of maximum flood flow. The reservoir is long and narrow. Its tributaries are of different sizes discharging into the reservoir at regular intervals. Thus, the peak of the runoff from tributary areas will reach the dam at different times resulting in a smoothing out effect on the maximum flood peak.

Discharge Capacity

The flood peak inflow of 7650 c.f.s., when routed through the reservoir, reduces to a flow of about 2000 c.f.s. which must be handled by the spillway and gates. This routing is based on the assumption that, with the present length spillway (19'-6"), the dam is high enough to permit the water level to rise 8 ft. above the crest. The present height of dam is 6 ft. above the crest, which would be overtopping, and, in all probability, result in failure. The water level at beginning of the flood is taken as 4 ft. above the crest, and at the same time stoplogs are removed and gates are open for full discharge.

The writer also routed the flood based on Prof. Barrows' recommendation of a 50 ft. spillway. For this larger spillway, the increase in water level

indicated in Table 1.

Table 1 - Record Flood Peaks* (Within 50 Mi. Radius of Norton Dam).

Item No.	Stream	Location	Drainage Area (sq.mi.)	Discharge (c.f.s. per sq.mi.)
1	Peabody River	Gorham, N.H.	40	248
2	Peabody River	Glen House, N.H.	17.4	421
3	Mohawk River	Colebrook, N.H.	32	166
4	Israel River	Lancaster, N.H.	124	71
5	Passumpsic River	St. Johnsbury, Vt.	237	139
6	Ammonoosuc River	Bethelehem, N.H.	97	185
7	Ammonoosuc River	Littleton, N.H.	124	134
8	Tomifobia River	Derby Line, Vt.	58	167
9	Missisquoi River	Richford, Vt.	445	101
10	Missisquoi River	Sheldon Springs, Vt.	809	78
11	Lamoille River	Cadys Falls, Vt.	280	131
12	Coaticook River	Coaticook, Quebec, Canada	150	160**

* Source of data - USGS Water Supply Paper 636-C
** Letter, dated 6/7/48 from Coaticook River Water Power Co.

A plot of the floods was made in Fig. 1 and an enveloping curve drawn according to the Creager formula. This curve indicates the flood producing characteristics of the streams in the vicinity of Norton Dam. As a comparison, a similar curve for the record floods of Vermont is shown in Fig. 1.

Thus, for a drainage area of 18 sq. mi. at Norton Dam, the curve indicates a flood peak of 425 c.f.s. per sq. mi. or a total of 7650 c.f.s. for the watershed. This value is 10 per cent over Prof. Barrows' estimate, but close enough for agreement.

Mr. Adams, in his June 7 letter, gives a flood peak of 160 c.f.s. per sq.

Previous Reports on Norton Dam

Previous reports concerning the situation at Norton Dam are briefly reviewed as follows: Prof. H. K. Barrows, Consulting Engineer, submitted to the Public Service Commission a report, dated May 9, 1945, in which he states that the dam is inadequate in spillway capacity and unsafe because of its susceptibility to overtopping and consequently failure. He recommended that the dam be increased in height about 3 to 4 ft. and the spillway capacity increased 2 or 3 times in length.

In response, E. Brown and H. W. Lea, Consulting Engineers, prepared a report dated December 3, 1947 for the Coaticook River Water Power Company, owner of dam, in which they maintain that the existing dam is adequate for its intended purpose. No data is presented. They conclude that with proper maintenance and operation the dam will continue to function as it has in the past 55 years.

After a conference before the Public Service Commission during which statements in the aforementioned reports were aired, Prof. Barrows, in a letter dated February 3, 1948, reaffirmed his recommendations for a 3 ft. increase in the height of the dam and a spillway increased to 50 ft.

A letter dated June 7, 1943 was received by this Commission from Mr. C. W. Adams of the Coaticook River Water Power Company in which he states that the company's stand is based on a study of rainfall and stream flow records. No data is presented. Mr. Adams also asserts that Prof. Barrows' flood peak of 7000 c.f.s. at the site is a remote possibility.

Flood Flow

The flood peak obtained by writer for Norton Dam is based on the method given in Chapter 5 of "Engineering for Dams" by Creager, Justin and Hinds. Flood peaks for streams in the vicinity of Norton Dam were obtained for the November, 1927 Flood which is the greatest on record in Vermont. These are

seepage, it is suggested that the pond level be kept as low as possible, at least not higher than the level of 3 ft. above the crest observed on date of visit to the site.

4. The maximum pond level, consistent with recommendation #1, should be limited to 4 ft. above the crest. With pond level at this elevation, full discharge for the system, that is, stoplogs removed and both sluice gates open, should be required if indications are that a storm will be of long duration.

5. Suitable slope protection should be provided for both upstream and downstream slopes.

6. The floating debris at the dam should be removed.

7. Remedial measures to be applied as soon as practicable.

Description of Dam

Norton Dam is an earth-fill dam about 1200 ft. long and from 8 to 10 ft. high. The top width averages about 13 ft. The side slopes are approximately 1 on 1 on the downstream side and 1 on 1½ on the upstream side.

At the westerly end of the dam is a concrete spillway structure with two crest openings, each 9'-9" long and separated by a 2 ft. pier. The spillway crest is 5 ft. below the top of the concrete structure and about 6 ft. below the top of the dam. Stoplogs of 3 in. plank control the flow over the spillway. A wooden plank bridge provides access over the structure.

Adjacent to the spillway, on the westerly side, are two concrete sluice ways, 5 ft. high by 4 ft. wide and 40 ft. long. Discharge is controlled by two hand operated slide gates. A concrete wing wall extends westerly about 50 ft. from the sluices to the end of the dam.

The reservoir behind the dam is about 0.3 mi. wide and 2.7 mi. long. It has a surface area of about 600 acres. The storage capacity or depth of the pond is not definitely known.

Norton Dam and reservoir are located on the Coaticook River in Essex County, Vermont about 5 mi. south of the Canadian ~~boarder~~ border.

8/12/48 Copies sent to Coaticook River Water Power Company, and Mrs. Glen Marshall.

REPORT ON NORTON DAM

Object and Scope

A study was made by the writer on the safety of Norton Dam in Essex County, Vermont. The findings are presented in this report.

This report is concerned only with those features of the dam which affect the safety of the structure as dictated by the requirements of the Public Service Commission. The legal procedure involved, as a result of the conclusions made herein, has been left to others.

Conclusions

The writer agrees with Prof. Barrows that the spillway capacity is inadequate for the present dam and failure may result due to overtopping. The writer further contends that, with the present condition of seepage, the dam is susceptible to sloughing of the downstream face which may result in failure of the embankment due to sliding.

Cognizance is taken of the effort made by the Coaticook River Water Power to improve the situation at Norton Dam. However, these remedial measures are inadequate in view of the unsatisfactory conditions found by this study.

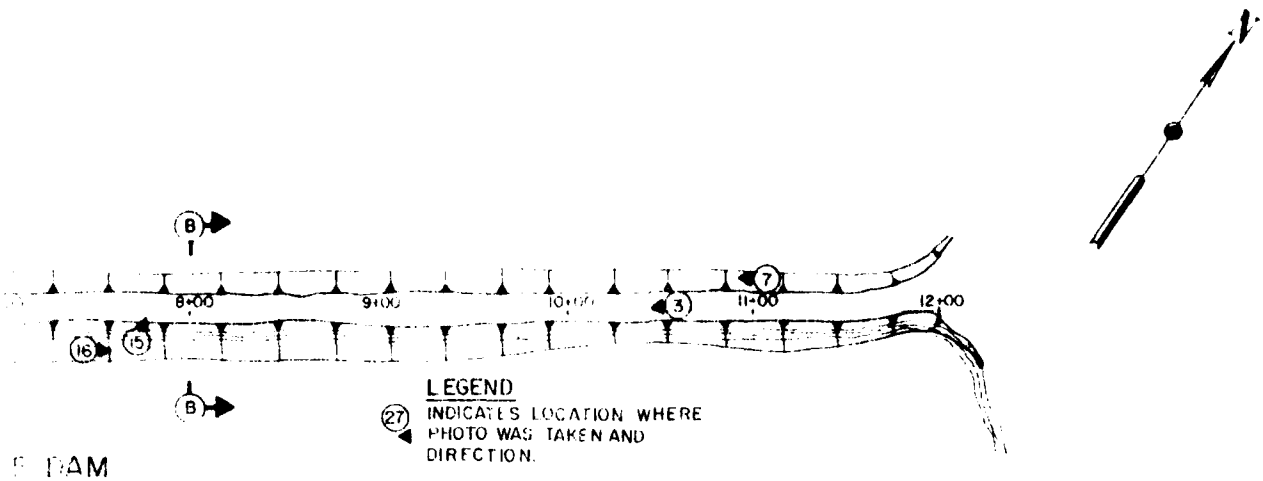
The following recommendations are made:

1. Raise the level of both the top of the dam and the concrete structure. If the spillway is kept at its present length of 19'-6" then, with a 3 ft. freeboard, the height of the dam should be 11 ft. above the crest. If the spillway is increased to 50 ft. then, with the same freeboard, the height of the dam should be 9 ft. above the spillway crest. It may be advisable to determine an economic balance between height of dam and length of spillway.

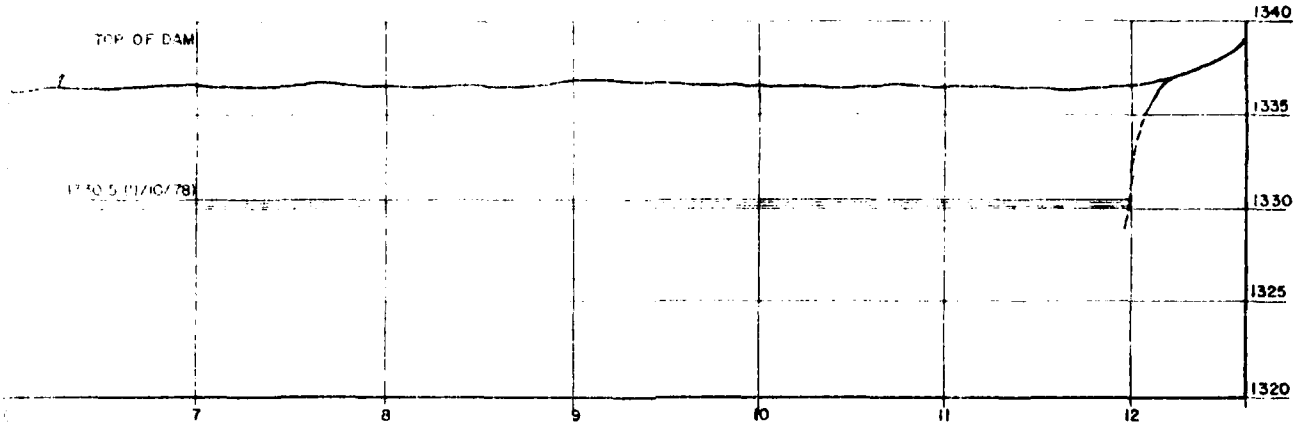
2. With an increase in the height of the dam the base should also be widened. A rock toe with filter protection, or other suitable means should be employed to protect the downstream toe from sloughing.

3. Until measures are taken to remedy the present conditions of

PAST INSPECTION REPORTS



DAM



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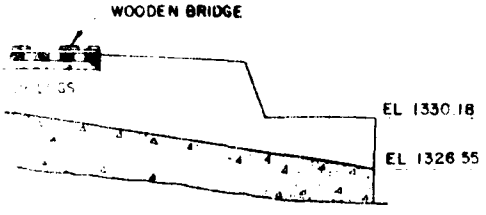
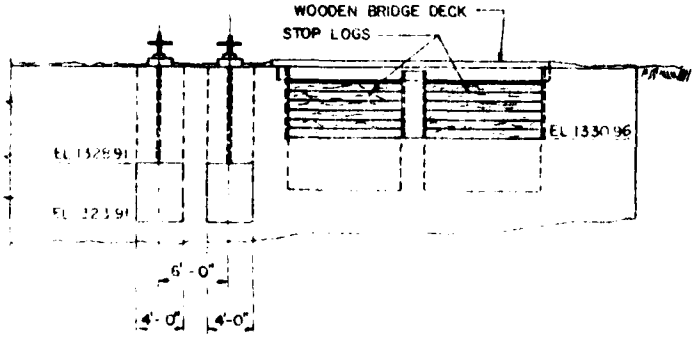
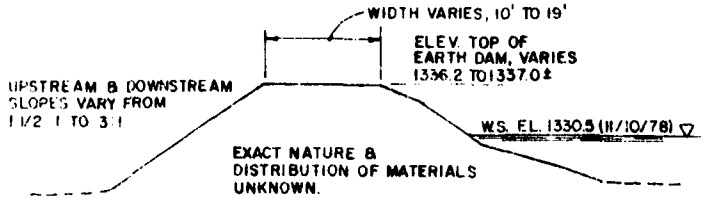


SECTION A-A

(SECTION THRU SPILLWAY)



ELEVATION OF GATES & SPILLWAY



SECTION B-B

(SECTION THRU EARTH DAM)

NOTES:

1. THE INFORMATION SHOWN ON THIS DRAWING IS BASED ON DRAWINGS BY W.S. LEA, CONSULTING ENGINEER CONTAINED IN A REPORT DATED NOVEMBER, 1947 REPORTING ON THE DAMS CONDITION TO THE OWNER, THE COATICOOK RIVER WATER POWER COMPANY. THIS INFORMATION WAS CHECKED DURING THE FIELD INSPECTION EXCEPT DIMENSIONS OR MATERIALS WHICH WERE BELOW GRADE OR WATER DURING THE INSPECTION WERE NOT VERIFIED.
2. THE ELEVATIONS SHOWN ARE BASED ON AN ELEVATION OF 1335 SHOWN ON U.S.G.S. QUADRANGLE SHEET ASSUMED TO BE FULL POOL ELEVATION (TOP OF STOP LOGS).

[illegible]	U.S. ARMY ENGINEER DIV. NEW ENGLAND [illegible]

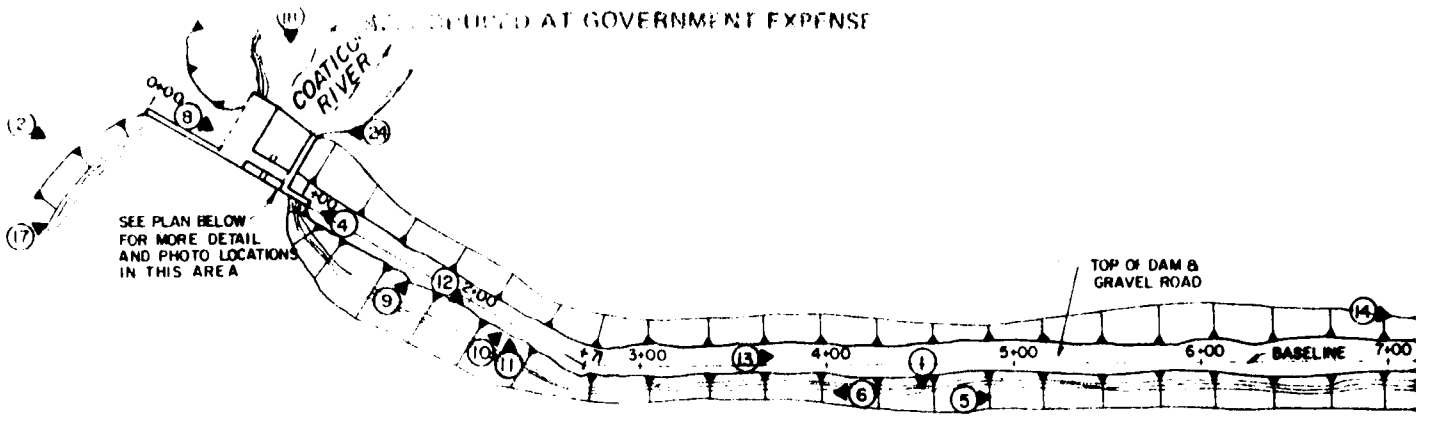
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

NORTON POND DAM

COATICOOK RIVER — NORTON, VERMONT

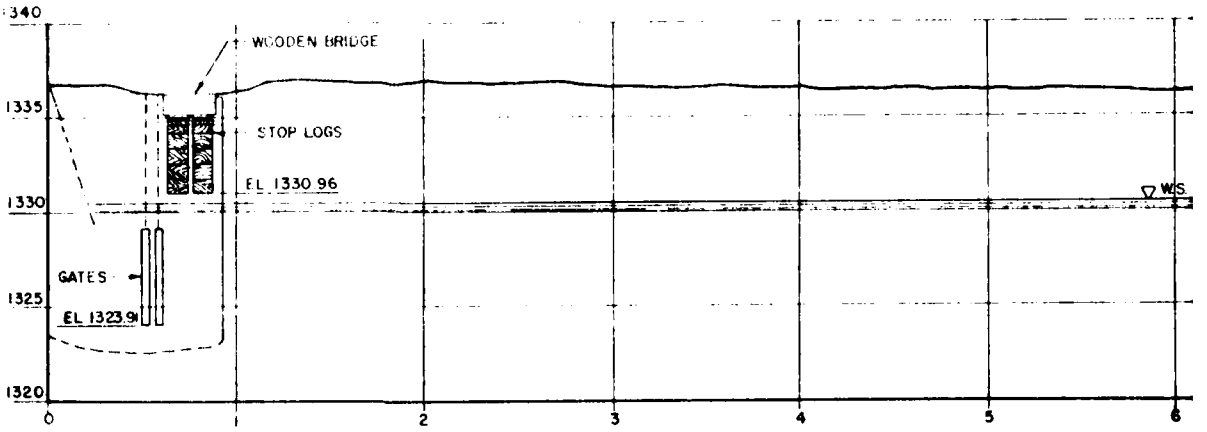
FIGURE 1

212



NORTON POND

PLAN OF



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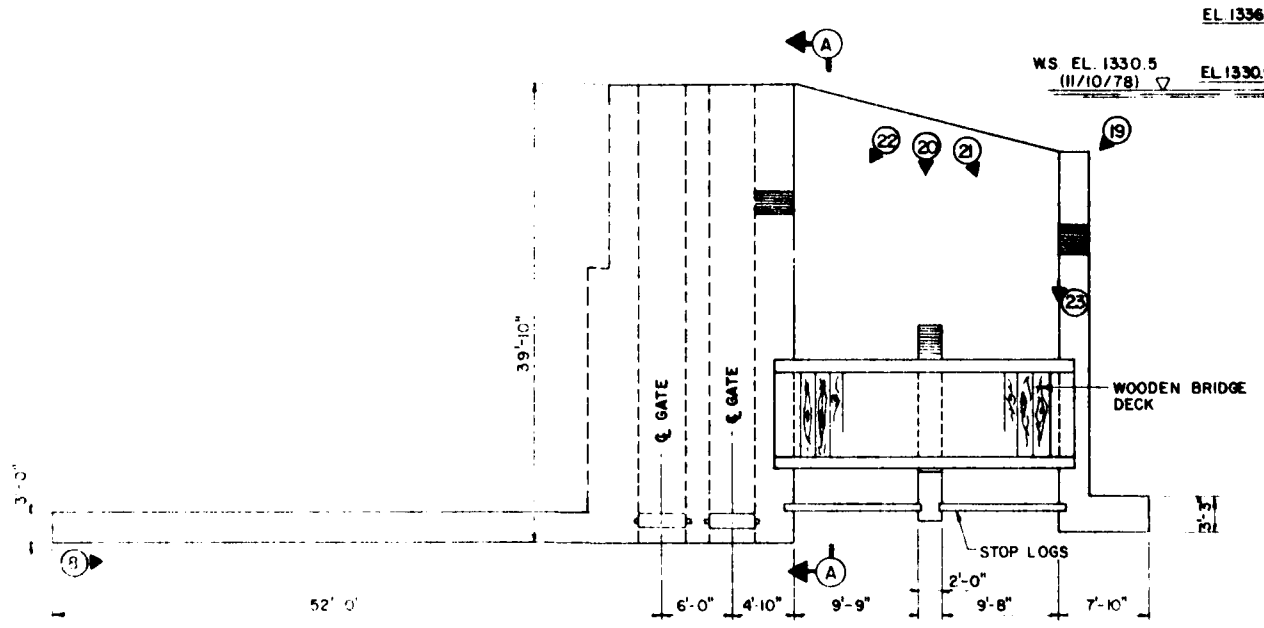


PLAN OF CONCRETE DAM & SPILLWAY

16/2

AVAILABLE ENGINEERING DATA

A set of drawings (2 sheets), prepared by W. S. Lea, Consulting Engineer, dated 1947, showing plan, sections and details of the existing dam are available at the State of Vermont, Public Service Board, Montpelier, Vermont 05602.

APPENDIX B

1. LIST OF DESIGN, CONSTRUCTION AND MAINTENANCE RECORDS
2. PLANS AND DETAILS
3. PAST INSPECTION REPORTS

PERIODIC INSPECTION CHECK LIST

PROJECT Norton Pond Dam — DATE Nov. 10, 1978

PROJECT FEATURE Service Bridge — NAME S. Mazur

DISCIPLINE Structural Engineer — NAME

AREA EVALUATED	CONDITION
OUTLET WORKS - SERVICE BRIDGE	
a. Super Structure	Log roadway bridge with transverse planks over spillway structure. Bridge is supported by spillway training walls and intermediate pier. No plates and no connections to the supports. Fair condition.
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Under Side of Deck	
Secondary Bracing	
Deck	Wooden planks.
Drainage System	None.
Railings	None.
Expansion Joints	None.
Paint	None.
b. Abutment & Piers	
General Condition of Concrete	Poor.
Alignment of Abutment	Good.
Approach to Bridge	
Condition of Seat & Backwall	Poor, cracks.

PERIODIC INSPECTION CHECK LIST

PROJECT Norton Pond Dam DATE Nov. 10, 1978

PROJECT FEATURE Spillway/Channel NAME D. LaGatta

DISCIPLINE Structural/Hydraulic/Geotechnical Engineers NAME S. Mazur, G. Slaney

AREA EVALUATED	CONDITION
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Many floating logs adjacent to approach area.
Loose Rock Overhanding Channel	None.
Trees Overhanging Channel	None.
Floor of Approach Channel	Below water surface.
b. Weir and Training Walls	
General Condition of Concrete	Fair.
Rust or Staining	Some staining.
Spalling	Heavy spalling.
Any Visible Reinforcing	At upstream face visible reinforcing.
Any Seepage or Efflorescence	None observed.
Drain Holes	None.
c. Discharge Channel	
General Channel	Same as outlet works channel.
Loose Rock Overhanging Channel	
Trees Overhanging Channel	
Floor of Channel	
Other Obstructions	

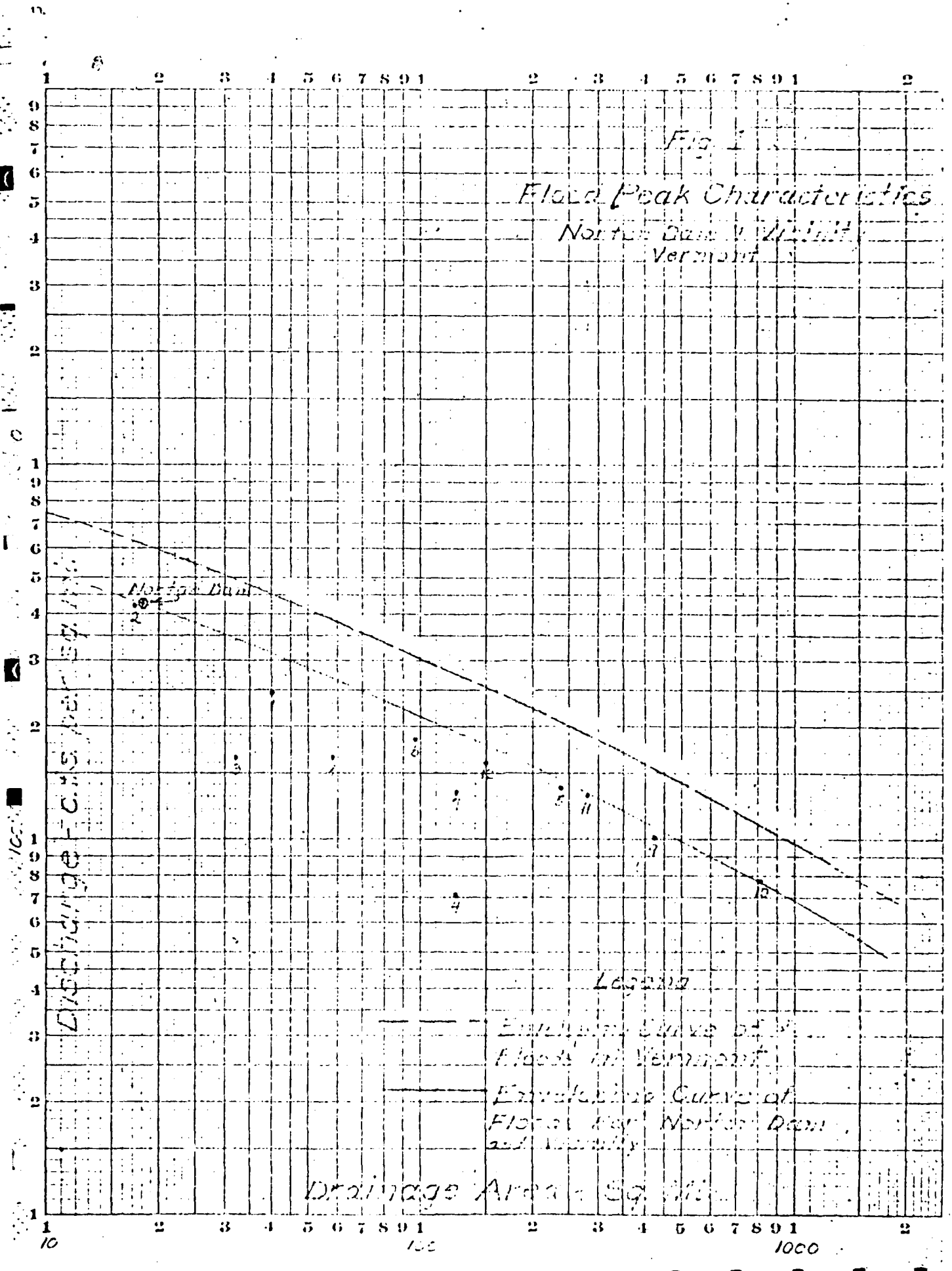


Fig. 1
Flood Peak Characteristics
North Dam
Vermont
Norfolk Dam
Legend
Envelope Curve of
Floods in Vermont
Envelope Curve of
Floods at Norfolk Dam
and Locality
Drainage Area - Sq. Mi.
10
100
1000

Flood Control
Projects
Norton

August 23, 1949

Mr. E. E. Akhurst, President
Coaticook River Power Company
Coaticook, Quebec

Dear Mr. Akhurst:

It has been brought to the attention of this Commission — through Mr. Glen Marshall, of Norton, and Mr. John H. Boylan, of Island Pond — that the water level at Norton Lake, which is controlled by your dam, is some 26 inches below the maximum drawdown level that was agreed upon by your company and certain interested parties. These gentlemen are also of the opinion that water has been released, at times, in excess of the amount needed to operate the hydro plant of the New Hampshire Electric Cooperative, Inc.

They also report evidence of seepage through and under the dam. This condition was noted by our hydraulic engineer in 1948 and we have ordered a further investigation to determine if seepage is increasing.

We would appreciate your advice on the apparent excessive drawdown and what measures will be taken to correct this condition and to prevent similar drawdowns in the future.

Very truly yours,

PUBLIC SERVICE COMMISSION

By:

G. W. CLEELEY
CHIEF ENGINEER

GWC:bcl

REPORT ON

NORTON LAKE EARTH-FILL DAM

COATICOOK RIVER

By

E.BROWN & H.W.LEA

Montreal, Que.

November, 1947.

MEMBER
E.I.C.
CORP. PROF. ENGRS. QUE.
AM. SOC. C.E.
A.W.W.A.
N.E.W.W.A.

LANCASTER 6093
1226 UNIVERSITY STREET

W. S. LEA
CONSULTING ENGINEER
MONTREAL

December 3rd., 1947.

Messrs. Coaticook River Water Power Company,
Box 399,
Coaticook, P.Q.

Gentlemen:-

REPORT ON
NORTON LAKE EARTH-FILL DAM
COATICOOK RIVER

Earlier this year, the late Mr. W.S. Lea, at your request, made an inspection of the above mentioned dam and the adjacent terrain, and initiated a search for information pertinent to the problem with which you are faced. This report is based on the information which he assembled, together with other data subsequently secured, and in accordance with our understanding of your wishes, is concerned with the adequacy of the existing dam to serve its intended purpose.

DESCRIPTION OF STRUCTURE

In the descriptive passages which follow, wherever the adjectives "left" and "right" appear in connection with the dam or the river and its banks, etc., reference is being made to the picture which presents itself to an observer looking downstream towards the object under discussion.

Norton Lake Dam was built about 55 years ago as a plain earth-fill structure with a timber spillway section. In 1922 the timber construction was replaced by a concrete spillway with centre pier and two stop log openings. A concrete wingwall was also built from the new spillway to the left end of the dam. Two sluice gates 4' wide x 5' high are set into this wall and discharge through concrete passages of rectangular section parallel to the spillway and extending downstream for the same distance.

A drawing marked Plan No.1, showing a plan and profile of the dam and details of the spillway, is attached to this report.

DESCRIPTION OF PARTIAL FAILURE OF DAM

During the afternoon of April 10th, 1945, a partial failure of the dam occurred, caused by the impounded water making its way over or through the earth-fill section at or near the right hand concrete wall of the spillway. The sluice gates were closed at the time, and although positive evidence in the form of records of information is lacking, there is a strong inference that all the stop logs, or at least all but one, were in place. The only approach to the dam by road is from the right bank, and since the breach in the earth-fill dam was between that bank and the spillway, it became necessary to cross the pond by skiff and approach the spillway from the left bank before the sluice gates could be opened and the stop logs removed. The situation was quickly brought under control, a triangular section of the earth fill being washed out to a depth of approximately 3 feet against the concrete spillway wall, decreasing gradually and petering out at a point 150 feet or so in the direction of the right bank. The wash-out was repaired by means of earth fill taken from the same pit in the neighbouring hillside as was used when the dam was built and repairs were completed on May 16th., 1945.

COMMUNICATION FROM VERMONT PUBLIC SERVICE COMMISSION

Acting upon a complaint, the Public Service Commission of the State of Vermont made an inspection of the dam on May 1st., 1945, and on May 28th., 1945, the Chairman of the Commission wrote to Mr. C.A. Swanson, with a copy to the Coaticook River Water Power Company listing five recommendations with respect to the structure and asking that these be implemented. A copy of this letter marked "Exhibit A" is attached hereto. These recommendations are commented upon individually under the sub-headings which follow.

Recommendation No.1.

Plan No.1, referred to earlier, implements the major part of this recommendation, with the exception that soundings for the establishment of cross sections of

the pond upstream from the dam do not appear to have been taken. These sections, if secured, will be of no practical use to the users of the storage water under existing conditions. In view of the history of the operation of the dam over the past fifty years, as discussed later in greater detail, it appears doubtful whether they will be of much value to officers of the Commission. However, if the Commission continues to press the point, you may feel that it will be desirable to do the necessary field work this winter, when soundings can be taken through the ice. Three lines of soundings spaced at intervals of the order of 500 feet upstream from the earth-fill dam should be quite adequate.

Recommendation No.2.

The material used in the earth-fill dam was taken from a pit in the hillside adjacent to the left end of the dam. An inspection of this pit will provide all the information which could be secured by digging test pits in the dam. It would be too bad to start digging holes 12 feet deep in an embankment so thoroughly consolidated as this fifty year old dam now is, and we feel confident that when it is pointed out to the Commission that identical material may be inspected on the pit face, the digging of test pits will not be insisted upon.

Recommendation No.3.

This calls for, (a) raising the dam 3 feet to 4 feet and widening the base and (b) widening the spillway to twice or three times its present width.

No continuous records have been taken of the stream flow of the Coaticook River at any point on the watershed, nor is there any rainfall gauging station on this watershed. However, stream flow and rainfall records have been kept for many years at a number of points both in the U.S. and Canada within a fifty mile radius of the dam. Inspection of these records shows that there was no rainfall at any of these stations on Apr. 10th., 1945, the day of the wash-out, and practically no rainfall for five days previous. Neither was there any indication of abnormal flow conditions on the adjacent streams for which run-off records are kept. As a matter of fact, the stage of the river at Coaticook was such that the water released by the wash-out did no damage whatsoever. On the other hand, the dam handled the record floods of November 1927, June

1942 and June 1943 without difficulty, in spite of the fact that the flows at these dates were much greater; that of June 1943 having an estimated peak at Coaticook, Quebec of 22,000 c.f.s. In other words, the dam has been operated in such manner as to take care of the highest flood flow ever recorded on the river.

Attached hereto, marked Plan No.2., are cross sections of the existing earth-fill dam taken at 100 feet intervals. Outstanding American engineering authorities are in general agreement that a top width of 6' is adequate for an earth filled dam not more than 25' high, and that for a mixture of clay and gravel the upstream slope may be 2:1 and the downstream slope 1 1/2:1. Such a section is shown on Plan No.2. for comparison with the actual sections. An inspection of this plan and recognition of the fact that the dam has been in use for over 50 years would seem to give ample assurance that the structure is adequate for its purpose.

Presumably the recommendation to increase the height of the earth-fill dam does not contemplate increasing the height of the spillway piers and walls by the same amount. Increasing the height of the earth-fill section alone would prevent water from overtopping that section, if, due to improper operation of the stop logs and gates in the wpillway, the water level were allowed to rise so as to submerge the existing concrete structure. Should this happen, the removal of stop logs and opening of gates would be extremely difficult, it not impossible, without considerable delay. A much more desirable safeguard would be to insure that the dam is inspected at regular and designated periods, and that the outflow is properly controlled at all times. The most critical periods would be when the reservoir is full, or is being filled, and during abnormally heavy rainfalls occurring at any time of year when the reservoir is fairly well filled.

The existing spillway and sluice gates have, in the past, dealt with situations of extremely high runoff and with a dependable operational procedure there should be no difficulty in handling future floods. The wash-out of Apr. 10th., 1945 cannot be properly charged to lack of spillway capacity.

Recommendation No.4.

The opinion which has been expressed in dealing with Recommendation No.3., against increasing the height and width of the earth-fill dam or the size of the spillway, directly affects Recommendation No.4. which concerns new construction. A frank discussion with the Members of the Vermont Public Service Commission and their technical advisors should secure agreement to the withdrawal of these Recommendations

subject to proper maintenance of the dam and dependable operational procedures.

Recommendation No.5.

Presumably this Recommendation refers only to floating logs etc. which might be drawn through the dam and jam in the stop log openings, and not to material which has lodged firmly along the upstream face of the earth-fill dam, and may be expected to remain there, During our visit to the dam, it was remarked that a floating boom protected the sluice gates and spillways, being anchored to the left bank of the lake some distance upstream from the face of the dam and extending out beyond the spillway section to another anchorage on the face of the earth-fill dam. It may be that it is already your practice to dispose of any loose floating debris which collects along the face of the dam. If not, it would be desirable to have this done at regular intervals. Disposal would be relatively inexpensive, and for material which has no salvage value, the most convenient procedure would probably be to remove a stop log for a short time and guide it through the spillway section.

That part of Recommendation No.5. concerning an adequate bridge across the spillway would appear to have been already implemented since we drove across to the left bank of the river during our inspection. Assuming this wooden span is properly anchored to the concrete so that it cannot be accidentally dislodged it provides a suitable roadway.

CONCLUSIONS

It is our understanding that the Vermont Public Service Commission have agreed to a meeting for discussion of the Recommendations contained in their letter of May 28th, 1945.

When this meeting takes place, you will be able to provide the Commission with detailed drawings of the existing dam, to advise that a boom is in place, that floating debris is properly taken care of, and that there is an adequate bridge across the spillway. You can demonstrate logically that test pits will only provide information already available, and this at the risk of injury to the dam. Finally you can point to the history of operation of the dam in handling extremely high run-off peaks as proof that the existing structure is adequate to deal with future conditions such as may reasonably be anticipat

It is our opinion that the information, records and data which have been collected will make it extremely difficult for the technical advisors of the Commission to disagree with the conclusion that the existing dam, if properly maintained and operated, can continue to function efficiently.

H.W. Lea.

E. Brown.

H. K. BARROWS
M. AM. SOC. C. E.
CONSULTING ENGINEER
8 BEACON STREET
BOSTON

May 9, 1945.

Fletcher Hamlin, Esq., Chairman,
Public Service Commission,
State of Vermont,
Montpelier, Vt.

Norton Pond Dam

Dear Sir:

As requested by you, I submit the following report on the Norton Pond Dam, located in Essex County, Vermont about five miles southerly from the Canadian line.

Norton Pond

Norton Pond has a tributary drainage area of 18 sq. miles and pond water area of about 600 acres. It is at about elevation 1335 ft. above mean sea level and its drainage area rises to about El. 2820 at Middle Mt. in its eastern portion and El. 2510 at Beech Nut Ridge in the west, and to El. 1800 on the north. Its average elevation is about 1800 ft. and its land slopes fairly steep, tending to a quick runoff.

The storage capacity of the pond is not definitely known but it is probably about 3000 acre feet or more or approximately 3 inches depth on the drainage area of 18 square miles.

Norton Pond is in the headwaters of Coaticook River which flows northward into the province of Quebec, its waters eventually reaching the St. Lawrence River.

Norton Pond Dam

An inspection of the Norton pond outlet and dam was made by the writer on May 1, in company with Chairman Plumley and Mr. Sinclair of the Commission and Mr. Clewly, its engineer. The dam involves an earth embankment about 800 ft. long and 8 to 10 ft. high, and is about 10 ft. wide at the top, with side slopes 1 on 1 on the downstream side and a little flatter on the upstream side. At the westerly or river end is a spillway structure of concrete with two crest openings each 10 feet long with a 2 ft. pier between. The spillway crest is about 6 ft. below the elevation of the top of the earth dam, and flashboards about 3 ft. high, of 3 in. plank were on the spillway at the time of the visit. Pond water surface was about 4 inches below the top of the flashboards and about 2 ft. below full pond level. Just westerly from the spillway are two hand operated waste gates covering two openings 4 ft. wide by about 5 ft. high, which discharge through concrete passages to the river below the dam.

Condition of Dam

The original portion of the earth embankment dates back possibly 60 years or more; the concrete spill-

way portion is about 15 years old and in fairly good condition. On April 10, 1945 a section of the earth embankment about 100 ft. long adjacent to the spillway failed by sliding, releasing about 2.5 feet depth of pond water. This portion of the earth dam had been nearly all replaced on May 1st.

On June 15, 1945, due to very high rainfall, with both waste gates open and flashboards off the spillway, pond water level reached the top of the earth dam. The dam was saved by the use of sand bags and since has been raised in top level about 1 ft. by adding earth fill.

Flood Capacity of Dam

Allowing 3 ft. of freeboard for the present earth dam maximum water level would be 3 ft. above the elevation of the spillway crest. With flashboards off this would give a discharge of about 300 c.f.s. over the spillway and 500 c.f.s. through the gates or a total discharge capacity of 800 c.f.s.

If the water level was raised to within a foot of the top of the dam, the spillway and gates would discharge about 1200 c.f.s. This is not, however, a safe procedure for the earth dam.

A flood runoff of at least 4 inches in 24 hours should be provided for. This would be an average daily flow of nearly 2000 c.f.s. and a peak flow of 3700 c.f.s.

or more, which with gates open would overtop the present dam and probably cause its failure.

A study of rainfall conditions in June 1943, taking into account the elevation of the Forton Pond drainage area indicates that between June 11 - 16 inc. about 8 to 9 inches of rain probably fell in the vicinity. In the first ten days of June an additional amount of about 1 inch of rainfall had fallen. In the month of May rainfall was somewhat above normal so that conditions in June were favorable for runoff.

The 8 to 9 inches of rainfall in six days probably produced 6 inches of runoff and failure of the dam was only prevented by emergency action in placing sand bags along the top of the earth dam.

It is obvious that the present dam is inadequate in spillway capacity and unsafe, as a somewhat larger or more concentrated rainfall than that in 1943, or perhaps a pond at higher elevation, would probably breach the earth dam and cause it to fail.

Conclusion

In my judgment the following proceedure is desirable:-

1. An accurate survey should be made of the present dam as a basis for a plan of the dam, with cross sections of the earth embankment each 100 ft. of length. Also a plan to show details of the spillway structure, gates

and abutment wall. Some cross sections with soundings should also be taken in the pond, to serve as a basis for the approximate determination of its capacity when full. At present, this capacity is unknown with any degree of accuracy.

2. Two or more test pits should be dug in the earth embankment to determine the character of the fill with which it is constructed. This should be done at a time when the water level at the dam is well drawn down.

3. Using the information obtained, a new plan should be made on the basis of raising the top of the earth dam 3 to 4 ft. and widening its base, and providing a spillway length of 2 to 3 times that of the present length of 20 ft.

4. Construction should then be carried out in an adequate and proper manner as soon as practicable.

5. The floating debris just above the dam should be kept removed and an adequate boom placed near the spillway, to prevent possible clogging of the gates under flood conditions. An adequate bridge on the spillway should also be provided.

Respectfully submitted,

H. H. Barrows

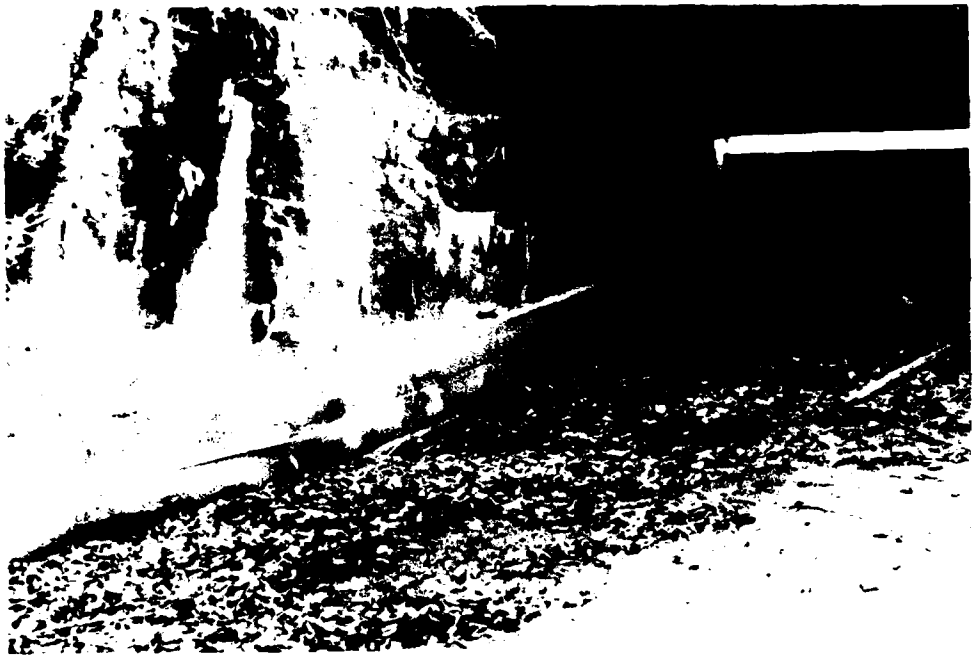


PHOTO NO. 21 - Spillway structure, detail of right training wall.

PHOTO NO. 22 - Spillway structure, detail of left training wall.

PHOTO NO. 19 - Close-up view of embankment at right training wall.

PHOTO NO. 20 - Close-up detail of spillway structure.

PHOTO NO. 17 - Appurtenant structures, view from upstream side.

PHOTO NO. 18 - Appurtenant structures (spillway and outlet works), view from downstream channel).

PHOTO NO. 15 - Slope failure at Station 7+64.

PHOTO NO. 16 - Upstream slope view from Station 7+50± towards right abutment.

PHOTO NO. 13 - Crest of dam from about Station 3+50 looking towards the right abutment.

PHOTO NO. 14 - Downstream slope of dam from about Station 7+00 looking towards right abutment.

PHOTO NO. 11 - Second view of the slope failure at Station 2+23. Rule equals 6 feet.

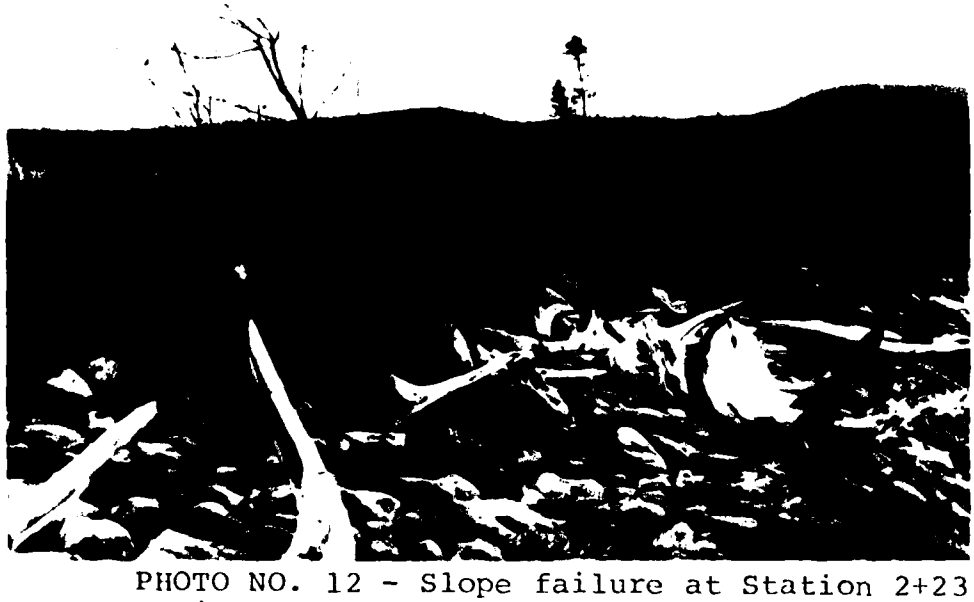


PHOTO NO. 12 - Slope failure at Station 2+23 viewed from crest of dam. The failure has extended to within 6 feet of the dam centerline and is about 50 feet long.

PHOTO NO. 9 - Slump in upstream face at Station 1+73. The soil is loose silty fine to coarse sand.

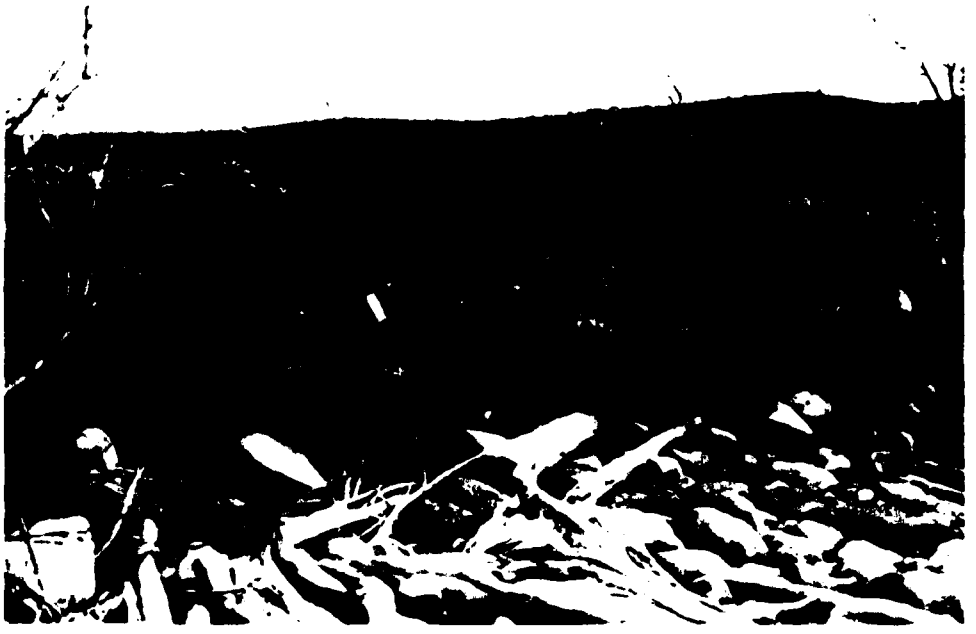


PHOTO NO. 10 - Slope failure in upstream face at Station 2+23.

PHOTO NO. 7 - Downstream slope of dam, view toward left abutment.

PHOTO NO. 8 - Retaining wall and appurtenant structures at left abutment.

PHOTO NO. 5 - Upstream slope of dam, view toward right abutment.

PHOTO NO. 6 - Upstream slope of dam, view toward left abutment.

PHOTO NO. 3 - Dam structure, view toward left abutment.

PHOTO NO. 4 - Dam structure at spillway and outlet works structures (at left abutment).

PHOTO NO. 1 - View of reservoir from dam structure.

PHOTO NO. 2 - General view of dam and reservoir from left abutment.

APPENDIX C

PHOTOGRAPHS

FOR LOCATION OF PHOTOS, SEE FIGURE 1
LOCATED IN APPENDIX B

4. Construction should then be carried out in an adequate and proper manner as soon as practicable.

5. The floating debris just above the dam should be kept removed and an adequate boom placed near the spillway, to prevent possible clogging of the gates under flood conditions. An adequate bridge on the spillway should also be provided.

May we be advised in the very near future of the action to be taken and when the recommendations above will be carried out?

Very truly yours,

Signed Fletcher Plumley

Chairman

FP:FS

cc: Mr. E.E. Akhurst, President
Coaticook River Water Power Company
Coaticook, P.Q.

COPY

"EXHIBIT A"

STATE OF VERMONT
PUBLIC SERVICE COMMISSION

Montpelier, Vermont
May 28, 1945.

Mr. C.A. Swanson,
Norton,
Vermont.

Dear Mr. Swanson:-

As a consequence of a complaint made to this Commission, an inspection of the Coaticook Power Company's Norton Dam, located in the Town of Norton, Vermont, was made on May 1, 1945.

The inspection party included the writer, Commissioner Sinclair, G.W. Clewley of the Commission's staff, and H.K. Barrows, hydraulic engineer retained by the Commission for this particular inspection.

The inspection made of the dam was sufficient to permit certain definite conclusions to be reached concerning the adequacy and the safety of the dam in question.

As a result of the investigation made, therefore, the opinion of the expert retained by us is to the effect that Norton Dam is inadequate in spillway capacity and unsafe, as a somewhat larger or more concentrated rainfall than that in 1943, or perhaps a pond at higher elevation, would probably breach the earth dam and cause it to fail.

In view of the inspection and the report made ot us, the following procedure is recommended to you:

1. An accurate survey should be made of the present dam as a basis for a plan of the dam, with cross sections of the earth embankment each 100 ft. of length.. Also a plan to show details of the spillway structure, gates and abutment wall. Some cross sections with soundings should also be taken in the pond, to serve as a basis for the approximate determination of its capacity when full. At present, this capacity is unknown with any degree of accuracy.

2. Two or more test pits should be dug in the earth embankment to determine the character of the fill with which it is constructed. This should be done at a time when the water level at the dam is well drawn down.

3. Using the information obtained, a new plan should be made on the basis of raising the top of the earth dam 3 to 4 ft. and widening its base, and providing a spillway length of 2 to 3 times that of the present length of 20 ft.

PHOTO NO. 23 - Erosion of left training wall at discharge channel.

PHOTO NO. 24 - Outlet works structure at discharge channel; erosion of concrete walls.

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/17/78	Job No 5628-11-22
	Checked by [illegible]	Date 1/17/79	Sheet No 1

For NORTON POND DAM

HYDRAULICS & HYDROLOGY

NORTON POND DAM Located in NORTON, Vt. along the Coaticook River in the Saint Lawrence River Basin

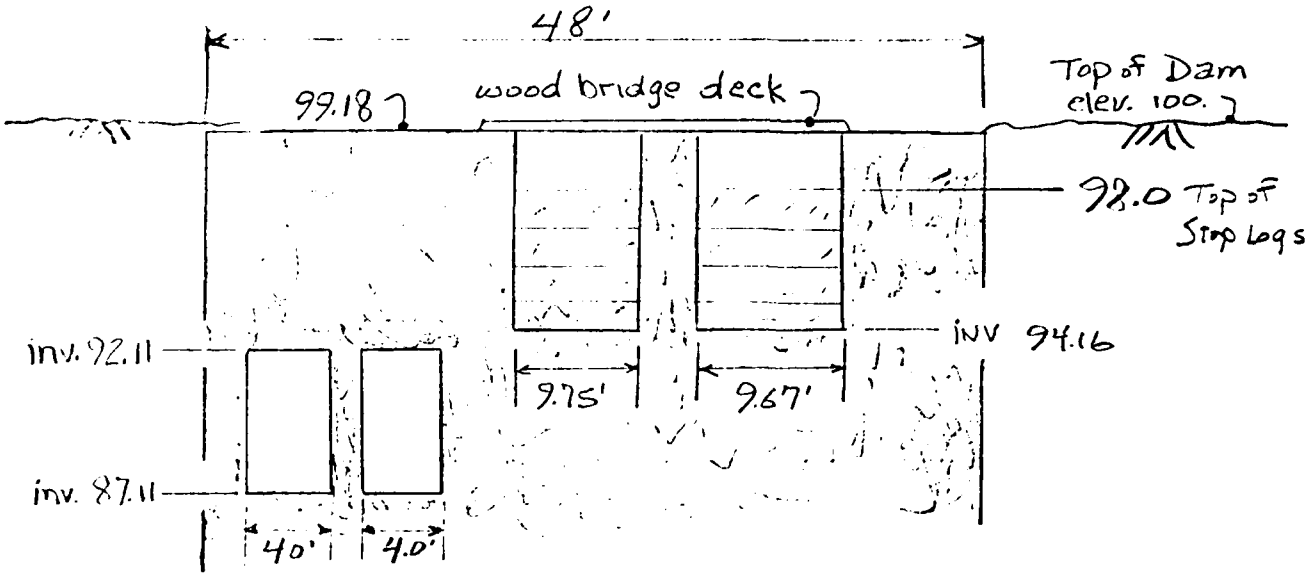
Classification Size: Intermediate.
HAZARD: Significant

Basic Data D.A. = 17.3 sq. mi. (HNTB calculation)
Upstream Basin: MOUNTAINOUS ave. slope 39% discounting upper 15% of streambed. Overall time of concentration is short due to many small streams entering reservoir rather than one major one.
Reservoir: Normal pool elev. 97.0*
storage 1950 acre-ft.
Max. pool elevation 100.0
Storage 3660 acre-ft.
Surface: 570 acres.
Dam: Earth
10' ave height - 12.3' max height
1200' long
Spillway: Concrete slab w/ piers
invert: elev. 94.16'
length: Total. = 19.42'
control: stop logs
Outlet: 2-4'x5' gates
invert: 87.11

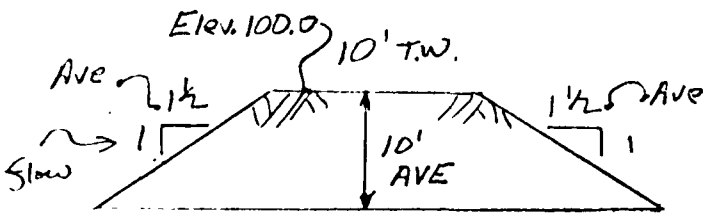
Note: Add 1236.8 to project datum for approximate USGS elevation

* Elevations used are project datum taken from existing plans.

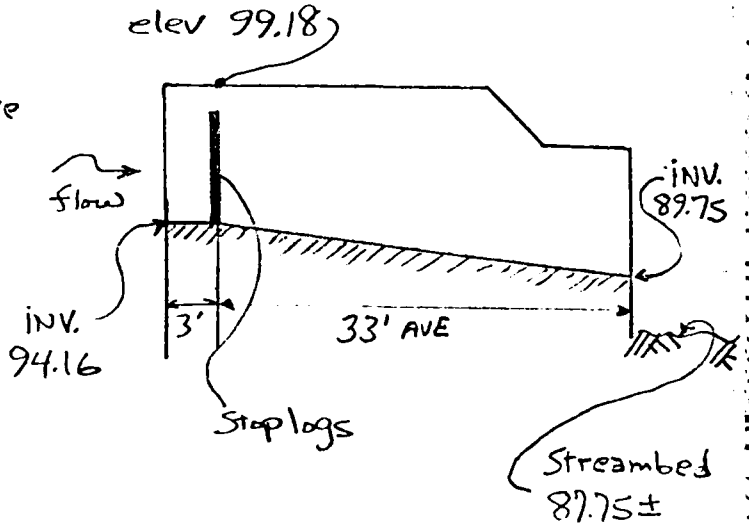
HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 11/17/78	Job No 5628-11-22
	Checked by	Date	Sheet No 2
For NORTON DAM			



Longitudal section along spillway
looking downstream



X-SECTION THRU DAM



X-sec thru spillway

HNTB
HOWARD NEEDLES TAMMEN & BERGENDOFF

Made by	RY	Date	11/17/78	Job No.	5628-11-22
Checked by	[illegible]	Date	1/17/79	Sheet No.	3

For NORTON DAM

Step 1 CALCULATION of Spillway Design Flood

Classification Size: intemediate
Hazard: Significant

Hydrologic Evaluation Guideline Recommends ½ to PMF use ½ PMF as Storage & height in lower range of classification guides
Basin - Mountainous therefore PMF = 1780 cfs/sq.mi.

½ × 1780 cfs/sq.mi. × 17.3 sq.mi. = 15,397 cfs.

USE ½ PMF 15400 cfs.

Step 2 Calculation of PMF Surcharge.

½ PMF = spillway design flood = 15,400 cfs.

Consider: 1. stoplogs in place as in inspection on 11/10/78 elev. 98.0 approx.
2. Gates in Closed Position.
3. Heavy growth of trees & shrubs will reduce any flow over dam crest It is estimated that flow will be reduced by approximately 30%

∴ Dam length - spillway section = length to be adjusted.

1200' - 48' = 1152'

1152 × (1 - .30) = 806 ft

806' + 48' = 854' Total length of broad crested weir for calculation of surcharge

Spillway: Length: total 19.42'
Crest: 98.0
Top of Dam 100.0 H at max pond = 2.0'

$Q_{S\,MAX\,Pond} = CLH^{3/2}$

$C_{sharp\,crested} = 3.22 + .4\left(\frac{H}{P}\right) = 3.22 + .4\left(\frac{2}{7}\right)$
$= 3.33$

$Q_S = 3.33(19.42)(2)^{3/2} = 183$ cfs
$= 183$ cfs.

Pressure flow over 100.0 elev. = Bridge deck

$Q_s = Ca\sqrt{2gh}$ where $C = .75$ for square orifice

$Q_s = 237.7\sqrt{h}$ $A = 19.75 \times 2 = 39.50'$

Spillway w/o stop logs only for MAX. Pond.
Total head = 100. - 94.11 = 5.89' non pressure
Assume wooden roadway deck will not influence flow.

Inlet control use U.S. Dept. of Commerce HEC #5

$\frac{\text{Headwater}}{\text{Height}} = \frac{5.89'}{5.89'} = 1$ = full flowing culvert at entrance

Discharge per ft. of width = 42 cfs/ft width

$19.42 \times 42 = 816$ cfs

DAM $Q_D = CLH^{3/2}$
where $C = 2.65$ Broad crest weir 10' T.W.
$L = 854'$ see pg 3

$Q_D = 2263(H)^{3/2}$

STAGE - DISCHARGE

Elevation project datum	Head Spillway	Q_S	Head DAM Top	Q_D	Q_{Total}
100.0	2.0 ft	183 cfs	0	-	180 cfs
101.0	3.0	410	1. ft.	2260 cfs	2670
103.0	5.0	530	3.0	11,760	12,290
104.0	6.0	582	4.0	18,100	18,600
105.0	7.0	630	5.0	25,300	25,930
106.0	8.0	670	6.0	33,260	33,930

see figure 1

STEP 3 Effect of Surcharge storage on PMF outflow

$Q_{P_1} = 15{,}400$ cfs

Surcharge elev $103.48 - 98. = 5.48'$

$$Stor_1 = \frac{5.48\ ft \times 12\ ^{in}/_{ft} \times 570\ acres}{17.3\ ^{sq\ mi}/_{mi} \times 640\ ^{acres}/_{mi^2}} = 3.38\ inches$$

$$Q_{P_2} = Q_{P_1}\left(1 - \frac{Stor_1}{9.5''}\right) = 15{,}400\left(1 - \frac{3.38}{9.5}\right) = 9{,}920\ cfs$$

$Surcharge_2$ = elev. $102.58 - 98. = 4.58$ ft

$$Stor_2 = \frac{4.58 \times 12 \times 570}{17.3 \times 640} = 2.83\ inches$$

$$Stor_{AVE\,1} = \frac{2.83 + 3.38}{2} = 3.11\ inches$$

$$Q_{P_3} = Q_{P_1}\left(1 - \frac{Stor_{AVE}}{9.5''}\right) = 15{,}400\left(1 - \frac{3.11}{9.5}\right) = 10{,}360\ cfs.$$

$Surcharge_3 = 102.66 - 98. = 4.66$

$$STOR_3 = \frac{4.66 \times 12 \times 570}{17.3 \times 640} = 2.88\ inches$$

$$STOR_{AVE2} = \frac{STOR_{AVG1} + STOR_3}{2} = \frac{2.88+3.11}{2} = 2.99 \text{ in}$$

$$Q_{P4} = QP_1\left(1 - \frac{STOR_{AVE2}}{9.5}\right) = 15{,}400\left(1 - \frac{2.99}{9.5}\right) = 10{,}553 \text{ cfs}$$

$Surcharge_4 = 102.70 - 98 = 4.70 \text{ ft.}$

$$STOR_4 = \frac{4.70 \times 12 \times 570}{17.3 \times 640} = 2.90 \text{ inches}$$

$STOR_3$ within 3% of $STOR_4$ no further iterations necessary
use QP_5 as outflow

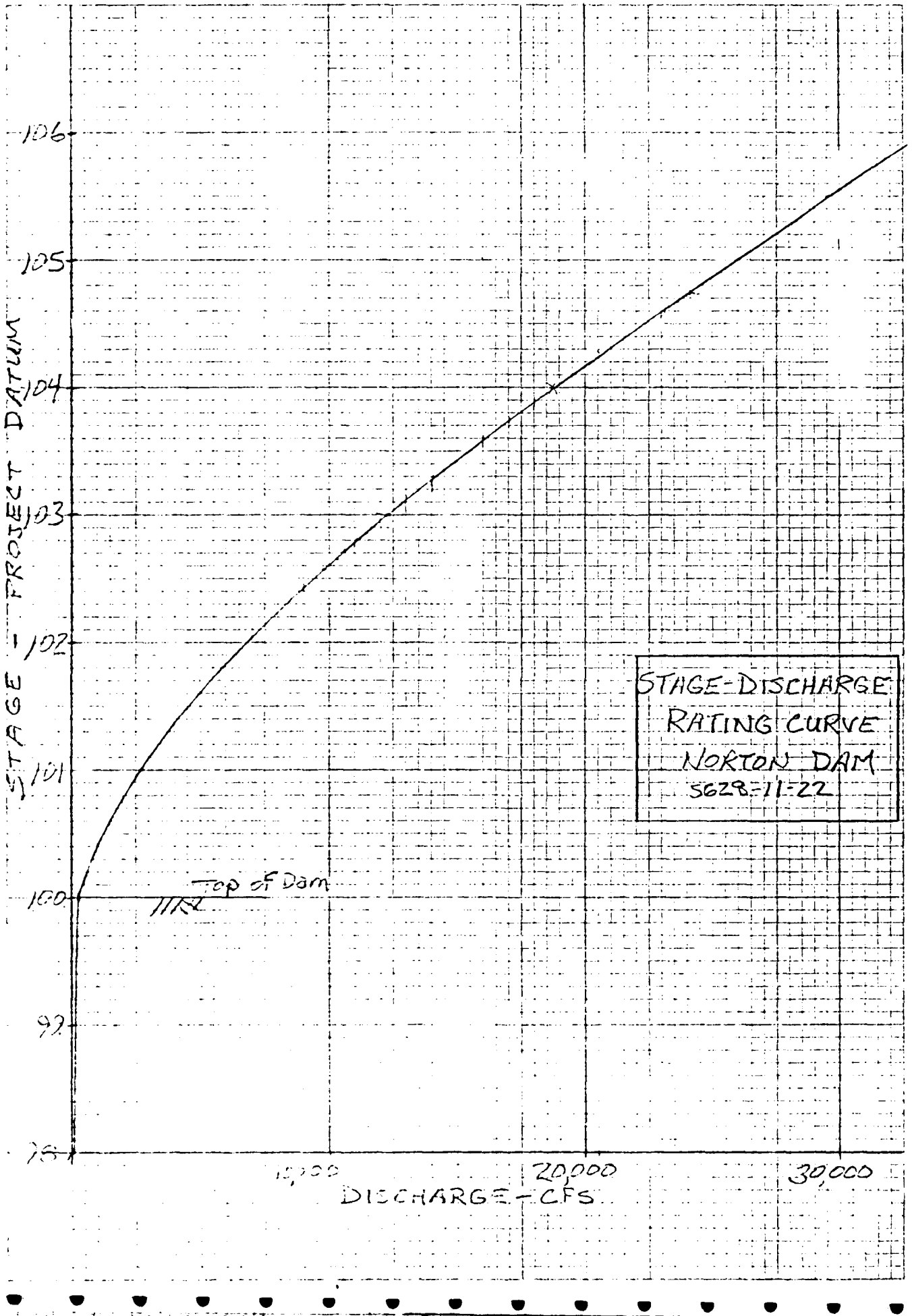
$$STOR_{AVE3} = \frac{2.90+2.99}{2} = 2.95 \text{ inches}$$

$$Q_{P5} = 15400\left(1 - \frac{2.95}{9.5}\right) = 10{,}618 \text{ cfs}$$

Reservoir Outflow 10,600 cfs

Conclusions

1. Reservoir Storage reduces the SDF from 15,400 cfs to 10,600 cfs or by 31 %
2. The spillway & Storage capacity can safely pass 5.0% of the routed test flood
3. At the test discharge of 10,600 cfs the dam crest will be overtopped by 2.70 ft. 102.70


106
105
104
103
102
101
100
99
98
STAGE - PROJECT DATUM
Top of Dam
1112
15,000
20,000
30,000
DISCHARGE - CFS
STAGE-DISCHARGE
RATING CURVE
NORTON DAM
5628-11-22

ESTIMATE of DOWNSTREAM DAMAGE

STEP 1 Reservoir Capacity

Normal Pool elev. 97.0 1950 acre-ft

Max. Pool elev 100.0 3660 acre ft

STEP 2 PEAK FAILURE OUTFLOW

$$Q_{P_1} = 8/27 \sqrt{g}\, W_b\, Y_o^{3/2}$$

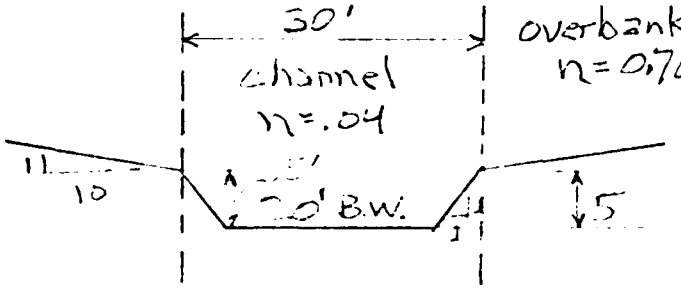
W_b = 40% of dam width = 1200(.4)

Y_o = Ave base of dam in valley to pool level.

$$Q_{P_1} = 8/27 \sqrt{g}\,(.40)(1200)(10)^{3/2} = 25{,}500 \text{ cfs}$$

$$Q_{P_1} = 25{,}500 \text{ cfs}$$

STEP 3 Stage discharge routing curve



Reach Characteristics

L_{total} = 26400'

S_{AVE} = .0032'/'

n: .04 channel
0.70 overbank

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by RY	Date 12/14/78	Job No 5628-11-22
	Checked by	Date 12/19	Sheet No 8

For Norton

Rating Curve Data

Stage	Channel Discharge	Overbank Discharge	Q_T
5	620	—	620
8	1540	140	1680
11	2760	900	3660
14	4250	2650	6900
16	5380	4520	9900

See Fig 2.

STEP 4 Downstream Damage Hydrograph.

Since the normal depth in the downstream channel at the breach discharge is well above the dam maximum height of 12.3 use the discharge given at stage 12.3 on the d.s. channel rating curve.

$Q_{P_1} = 5000$ cfs at stage 12.3.

$Area_1 = 880$ sq ft

$$V_1 = \frac{880 \times 26400}{43560} = 533 \text{ ac-ft}$$

$$Q_{P_{2\,Trial}} = 5000\left(1 - \frac{533}{3660}\right) = 4270 \text{ cfs}$$

$Stage_2 = 11.6$ ft $Area_2 = 742$ sq ft

$$V_2 = \frac{742 \times 26400}{43560} = 450 \text{ ac-ft}$$

$$V_{ave} = \frac{533 + 450}{2} = 491 \text{ ac-ft}$$

$$Q_{P_3} = 5000\left(1 - \frac{491}{3660}\right) = 4330 \text{ cfs @ Stage } 11.7 \text{ ft}$$

The calculated downstream flood wave is not diminished as per the preceeding calculations. Therefore, the approximate 2/3 rule for downstream stage should be used. 2/3 of the dam height would produce a downstream stage of 12.3 x .67 or 8.1 feet.

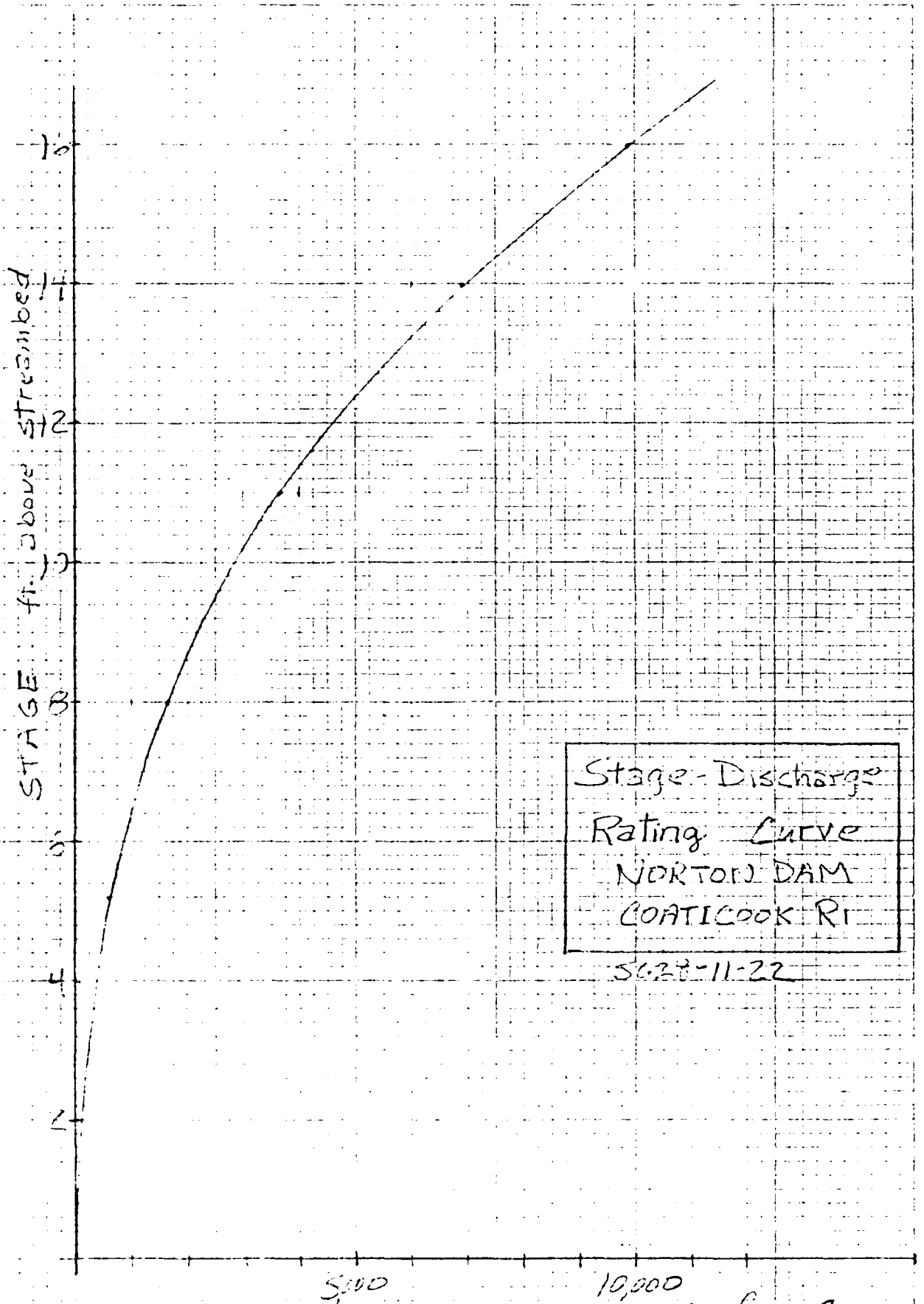
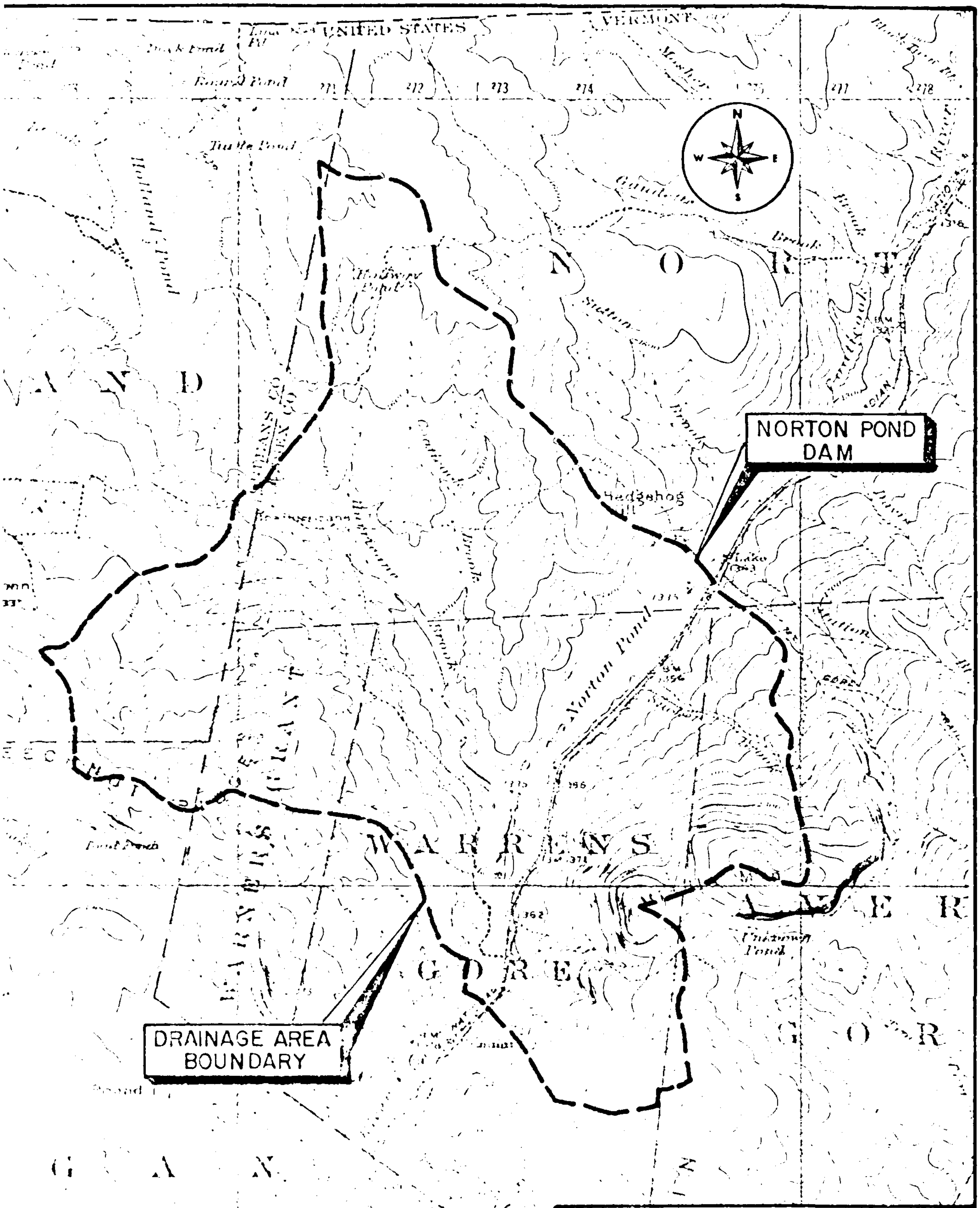

STAGE ft. above streambed
5,000
10,000
DISCHARGE cfs.
Stage-Discharge
Rating Curve
NORTON DAM
COATICOOK RI
SCS-11-22

figure 2



NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS

NORTON POND DAM

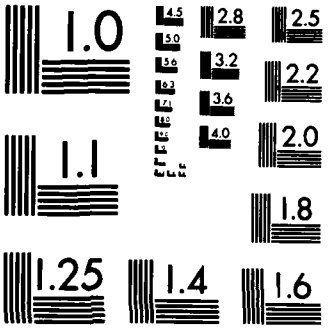
DRAINAGE AREA

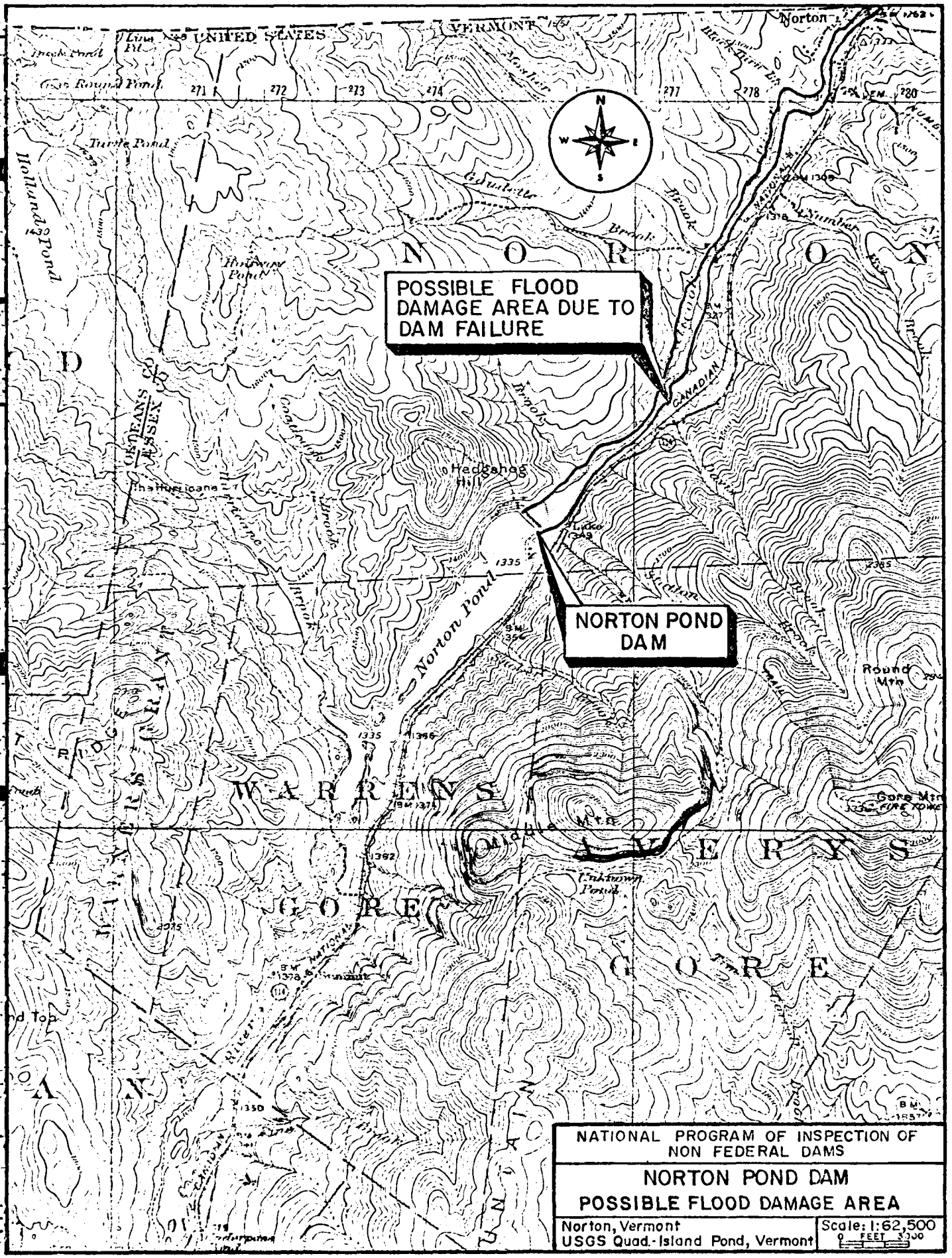
Norton, Vermont
USGS Quad - Island Pond, Vermont

Scale: 1:62,500

AD-A157 328 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS NORTON POND DAM (VT 0.. (U) CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV JAN 79 2/2

UNCLASSIFIED F/G 13/13 NL





NATIONAL PROGRAM OF INSPECTION OF NON FEDERAL DAMS

NORTON POND DAM
POSSIBLE FLOOD DAMAGE AREA

Norton, Vermont
USGS Quad.-Island Pond, Vermont

Scale: 1:62,500
0 FEET 3000

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

(1) STATE	(2) IDENTITY NUMBER	(3) DIVISION	(4) STATE	(5) COUNTY	(6) CONGR DIST.	(7) STATE	(8) COUNTY	(9) CONGR DIST.	(9) NAME	(10) LATITUDE (NORTH)	(11) LONGITUDE (WEST)	(12) REPORT DATE DAY	MO	YR
VT	104	[illegible]	VT	009	01				NORTON POND DAM	4857.2	7151.1	12	DEC	78

(13) POPULAR NAME	(14) NAME OF IMPOUNDMENT
NORTON POND DAM	NORTON POND

(15) REGION	(16) BASIN	(17) RIVER OR STREAM	(18) NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	(19) DIST FROM DAM (MI.)	(20) POPULATION
01	09	CONNECTICUT RIVER	NORTON	5	50

(21) TYPE OF DAM	(22) YEAR COMPLETED	(23) PURPOSES	(24) STRUCTURAL HEIGHT (FT.)	(25) HYDRAULIC HEIGHT (FT.)	(26) IMPOUNDING CAPACITIES MAXIMUM (ACRE FT.)	(27) NORMAL (ACRE FT.)	DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
EARTH	1966	S	10	10	3660	1950	FED	N	N	N	N	21FEB79

(28) REMARKS
22-FPATES 1967

(29) D/S HAS	(30) SPILLWAY CREST LENGTH	(31) TYPE	(32) WIDTH (FT.)	(33) MAXIMUM DISCHARGE (FT.)	(34) VOLUME OF DAM (CY)	(35) POWER CAPACITY INSTALLED (MW)	(36) PROPOSED (MW)	(37) NAVIGATION LOCKS NO.	(38) LENGTH (FT.)	(39) WIDTH (FT.)	(40) LENGTH (FT.)	(41) WIDTH (FT.)	(42) LENGTH (FT.)	(43) WIDTH (FT.)	(44) LENGTH (FT.)	(45) WIDTH (FT.)
N	1200	C	19	100	11100											

(46) OWNER	(47) ENGINEERING BY	(48) CONSTRUCTION BY
CONNECTICUT POWER CO.		

(49) REGULATORY AGENCY DESIGN	(50) CONSTRUCTION	(51) OPERATION	(52) MAINTENANCE
[illegible]	NONE	NONE	NONE

(53) INSPECTION BY	(54) INSPECTION DATE DAY	MO	YR	(55) AUTHORITY FOR INSPECTION
HOWARD NEEDLES TAMMEN BERGENDOFF	10	08	78	PUBLIC LAW 92-367 AUG 1972

(56) REMARKS
30-NATIONAL SAFETY 31-STOPLOGS 32-STOPLOGS IN PLACE

END

FILMED

9-85

DTIC